

FLEA HEAD, NERVE CORD, HINDGUT AND MALPIGHIAN TUBULE  
NUCLEIC ACID MOLECULES, PROTEINS AND USES THEREOF

CROSS REFERENCE TO RELATED APPLICATIONS

5 SUB  
AI } This application claims priority to U.S. Provisional Patent Application Serial  
Number 60/128,704, entitled "NOVEL FLEA HEAD, NERVE CORD, HINDGUT AND  
MALPIGHIAN TUBULE NUCLEIC ACID MOLECULES, PROTEINS AND USES  
THEREOF", filed April 9, 1999.

FIELD OF THE INVENTION

10 The present invention relates to nucleic acid molecules isolated from the head and  
nerve cord of a flea, nucleic acid molecules isolated from the hindgut and Malpighian  
tubule of a flea, proteins encoded by such nucleic acid molecules, antibodies raised  
against such proteins, and inhibitors of such proteins. The present invention also includes  
therapeutic compositions comprising such nucleic acid molecules, proteins, antibodies,  
and/or other inhibitors, as well as uses thereof.

15 BACKGROUND OF THE INVENTION

Flea infestation of animals is a health and economic concern because fleas are  
known to cause and/or transmit a variety of diseases. Fleas directly cause a variety of  
diseases, including allergies, and also carry a variety of infectious agents including, but  
not limited to, endoparasites (e.g., nematodes, cestodes, trematodes and protozoa),  
20 bacteria and viruses. In particular, the bites of fleas are a problem for animals maintained  
as pets because the infestation becomes a source of annoyance not only for the pet but  
also for the pet owner who may find his or her home generally contaminated with insects.

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As such, fleas are a problem not only when they are on an animal but also when they are in the general environment of the animal.

Bites from fleas are a particular problem because they not only can lead to disease transmission but also can cause a hypersensitive response in animals which is manifested  
5 as disease. For example, bites from fleas can cause an allergic disease called flea allergic (or allergy) dermatitis (FAD). A hypersensitive response in animals typically results in localized tissue inflammation and damage, causing substantial discomfort to the animal.

The medical importance of flea infestation has prompted the development of reagents capable of controlling flea infestation. Commonly encountered methods to  
10 control flea infestation are generally focused on use of insecticides. While some of these products are efficacious, most, at best, offer protection of a very limited duration. Furthermore, many of the methods are often not successful in reducing flea populations. In particular, insecticides have been used to prevent flea infestation of animals by adding such insecticides to shampoos, powders, collars, sprays, spot-on formulations foggers and  
15 liquid bath treatments (i.e., dips). Reduction of flea infestation on the pet has been unsuccessful for one or more of the following reasons: failure of owner compliance (frequent administration is required); behavioral or physiological intolerance of the pet to the pesticide product or means of administration; and the emergence of flea populations resistant to the prescribed dose of pesticide.

20 Thus, there remains a need to develop a reagent and a method to protect animals from flea infestation.

## SUMMARY OF THE INVENTION

The present invention relates to a novel product and process for protection of animals from flea infestation.

The present invention provides flea head and nerve cord (HNC) proteins and flea hindgut and Malpighian tubule (HMT) proteins; nucleic acid molecules encoding flea HNC proteins and flea HMT proteins; antibodies raised against such proteins (i.e., anti-flea HNC antibodies and anti-flea HMT antibodies respectively); mimetopes of such proteins or antibodies; and compounds that inhibit flea HNC or HMT activity (i.e., inhibitory compounds or inhibitors).

The present invention also includes methods to obtain such proteins, mimetopes, nucleic acid molecules, antibodies and inhibitory compounds. The present invention also includes the use of proteins and antibodies to identify such inhibitory compounds as well as assay kits to identify such inhibitory compounds. Also included in the present invention are therapeutic compositions comprising proteins, mimetopes, nucleic acid molecules, antibodies and inhibitory compounds of the present invention including protective compounds derived from a protein of the present invention that inhibit the activity of HNC and/or HMT proteins; also included are uses of such therapeutic compounds to reduce flea infestation.

One embodiment of the present invention is an isolated nucleic acid molecule that hybridizes with a nucleic acid sequence having SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:16, SEQ ID NO:18, SEQ ID NO:19, SEQ ID NO:21, SEQ ID NO:22, SEQ ID NO:24, SEQ ID NO:25, SEQ ID NO:27, SEQ ID

NO:28, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:33, SEQ ID NO:34, SEQ ID  
 NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID  
 NO:43, SEQ ID NO:45, SEQ ID NO:46, SEQ ID NO:48, SEQ ID NO:153, SEQ ID  
 NO:155, SEQ ID NO:156, SEQ ID NO:158, SEQ ID NO:159, SEQ ID NO:161, SEQ ID  
 5 NO:162, SEQ ID NO:164, SEQ ID NO:165, SEQ ID NO:167, SEQ ID NO:168, SEQ ID  
 NO:170, SEQ ID NO:1859, SEQ ID NO:1860, SEQ ID NO:1861, SEQ ID NO:1863,  
 SEQ ID NO:1864, SEQ ID NO:1866, SEQ ID NO:1867, SEQ ID NO:1869, SEQ ID  
 NO:1870, SEQ ID NO:1871, SEQ ID NO:1872, SEQ ID NO:1874, SEQ ID NO:1875,  
 SEQ ID NO:1876, SEQ ID NO:1877, SEQ ID NO:1878, SEQ ID NO:1880, SEQ ID  
 10 NO:1881, SEQ ID NO:1882, SEQ ID NO:1884, SEQ ID NO:1885, SEQ ID NO:1886,  
 SEQ ID NO:1887, SEQ ID NO:1889, SEQ ID NO:1890, SEQ ID NO:1891, SEQ ID  
 NO:1892, SEQ ID NO:1893, SEQ ID NO:1894, SEQ ID NO:1895, SEQ ID NO:1896,  
 SEQ ID NO:1898, SEQ ID NO:1899, SEQ ID NO:1900, SEQ ID NO:1901, SEQ ID  
 NO:1903, SEQ ID NO:1904, SEQ ID NO:1905, SEQ ID NO:1906, SEQ ID NO:1907,  
 15 SEQ ID NO:1908, SEQ ID NO:1909, SEQ ID NO:1910, SEQ ID NO:1911, SEQ ID  
 NO:1912, SEQ ID NO:1913, SEQ ID NO:1914, SEQ ID NO:1916, SEQ ID NO:1917,  
 SEQ ID NO:1918, SEQ ID NO:1919, SEQ ID NO:1921, SEQ ID NO:1922, SEQ ID  
 NO:1923, SEQ ID NO:1924, SEQ ID NO:1926, SEQ ID NO:1927, SEQ ID NO:1928,  
 SEQ ID NO:1929, and/or SEQ ID NO:1931 under conditions that allow less than or equal  
 20 to about 30% base pair mismatch. Another embodiment of the present invention is an  
 isolated nucleic acid molecule that hybridizes with a nucleic acid molecule selected from  
 the group consisting of a nucleic acid sequence of Table I, Table II, Table III and/or



Table IV, or a nucleic acid sequence complementary to a nucleic acid sequence of Table I, Table II, Table III and/or Table IV under conditions that allow less than or equal to about 30% base pair mismatch.

Another embodiment of the present invention is an isolated nucleic acid molecule

5 having nucleic acid sequence that is at least about 70% identical to SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:16, SEQ ID NO:18, SEQ ID NO:19, SEQ ID NO:21, SEQ ID NO:22, SEQ ID NO:24, SEQ ID NO:25, SEQ ID NO:27, SEQ ID NO:28, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:33, SEQ ID

10 NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45, SEQ ID NO:46, SEQ ID NO:48, SEQ ID NO:153, SEQ ID NO:155, SEQ ID NO:156, SEQ ID NO:158, SEQ ID NO:159, SEQ ID NO:161, SEQ ID NO:162, SEQ ID NO:164, SEQ ID NO:165, SEQ ID NO:167, SEQ ID NO:168, SEQ ID NO:170, SEQ ID NO:1859, SEQ ID NO:1860, SEQ ID NO:1861, SEQ

15 ID NO:1863, SEQ ID NO:1864, SEQ ID NO:1866, SEQ ID NO:1867, SEQ ID NO:1869, SEQ ID NO:1870, SEQ ID NO:1871, SEQ ID NO:1872, SEQ ID NO:1874, SEQ ID NO:1875, SEQ ID NO:1876, SEQ ID NO:1877, SEQ ID NO:1878, SEQ ID NO:1880, SEQ ID NO:1881, SEQ ID NO:1882, SEQ ID NO:1884, SEQ ID NO:1885, SEQ ID NO:1886, SEQ ID NO:1887, SEQ ID NO:1889, SEQ ID NO:1890, SEQ ID NO:1891,

20 SEQ ID NO:1892, SEQ ID NO:1893, SEQ ID NO:1894, SEQ ID NO:1895, SEQ ID NO:1896, SEQ ID NO:1898, SEQ ID NO:1899, SEQ ID NO:1900, SEQ ID NO:1901, SEQ ID NO:1903, SEQ ID NO:1904, SEQ ID NO:1905, SEQ ID NO:1906, SEQ ID

NO:1907, SEQ ID NO:1908, SEQ ID NO:1909, SEQ ID NO:1910, SEQ ID NO:1911,  
 SEQ ID NO:1912, SEQ ID NO:1913, SEQ ID NO:1914, SEQ ID NO:1916, SEQ ID  
 NO:1917, SEQ ID NO:1918, SEQ ID NO:1919, SEQ ID NO:1921, SEQ ID NO:1922,  
 SEQ ID NO:1923, SEQ ID NO:1924, SEQ ID NO:1926, SEQ ID NO:1927, SEQ ID  
 5 NO:1928, SEQ ID NO:1929, and/or SEQ ID NO:1931 and/or a nucleic acid sequence of  
 Table I, Table II, Table III and/or Table IV or complements thereof.

The present invention also relates to recombinant molecules, recombinant viruses  
 and recombinant cells that include a nucleic acid molecule of the present invention. Also  
 included are methods to produce such nucleic acid molecules, recombinant molecules,  
 10 recombinant viruses and recombinant cells.

Another embodiment of the present invention includes an isolated flea HMT  
 and/or HNC protein that is at least about 70% identical to an amino acid sequence  
 selected from the group consisting of SEQ ID NO:2, SEQ ID NO:8, SEQ ID NO:14, SEQ  
 ID NO:20, SEQ ID NO:26, SEQ ID NO:32, SEQ ID NO:38, SEQ ID NO:44, SEQ ID  
 15 NO:154, SEQ ID NO:160, SEQ ID NO:163, SEQ ID NO:169, SEQ ID NO:1862, SEQ  
 ID NO:1868, SEQ ID NO:1873, SEQ ID NO:1879, SEQ ID NO:1883, SEQ ID NO:1888,  
 SEQ ID NO:1897, SEQ ID NO:1902, SEQ ID NO:1915, SEQ ID NO:1920, SEQ ID  
 NO:1925, and/or SEQ ID NO:1930, and/or an amino acid sequence encoded by a nucleic  
 acid sequence of Table I, Table II, Table III and/or Table IV, and fragments thereof,  
 20 wherein such fragments can elicit an immune response against respective flea proteins or  
 have activity comparable to respective flea proteins.

Another embodiment of the present invention includes an isolated protein encoded by a nucleic acid molecule that hybridizes with the complement of a nucleic acid sequence having SEQ ID NO:1, SEQ ID NO:4, SEQ ID NO:7, SEQ ID NO:10, SEQ ID NO:13, SEQ ID NO:16, SEQ ID NO:19, SEQ ID NO:22, SEQ ID NO:25, SEQ ID NO:28, SEQ ID NO:31, SEQ ID NO:34, SEQ ID NO:37, SEQ ID NO:40, SEQ ID NO:43, SEQ ID NO:46, SEQ ID NO:153, SEQ ID NO:156, SEQ ID NO:159, SEQ ID NO:162, SEQ ID NO:165, SEQ ID NO:168, SEQ ID NO:1859, SEQ ID NO:1861, SEQ ID NO:1864, SEQ ID NO:1867, SEQ ID NO:1870, SEQ ID NO:1872, SEQ ID NO:1875, SEQ ID NO:1877, SEQ ID NO:1878, SEQ ID NO:1881, SEQ ID NO:1882, SEQ ID NO:1885, SEQ ID NO:1887, SEQ ID NO:1890, SEQ ID NO:1892, SEQ ID NO:1894, SEQ ID NO:1896, SEQ ID NO:1899, SEQ ID NO:1901, SEQ ID NO:1904, SEQ ID NO:1906, SEQ ID NO:1908, SEQ ID NO:1910, SEQ ID NO:1912, SEQ ID NO:1914, SEQ ID NO:1917, SEQ ID NO:1919, SEQ ID NO:1922, SEQ ID NO:1924, SEQ ID NO:1927, and/or SEQ ID NO:1929 and/or a nucleic acid sequence of Table I, Table II, Table III and/or Table IV, under conditions that allow less than or equal to about 30% base pair mismatch.

#### DETAILED DESCRIPTION OF THE INVENTION

The present invention provides for nucleic acid molecules isolated from the head and/or nerve cord of a flea, nucleic acid molecules isolated from the hindgut and/or Malpighian tubule of a flea, proteins encoded by such nucleic acid molecules, antibodies raised against such proteins, and inhibitors of such proteins. As used herein, nucleic acid molecules isolated from the head and/or nerve cord of a flea and proteins encoded by

such nucleic acid molecules are also referred to as flea HNC, or HNC, nucleic acid molecules and proteins respectively; and nucleic molecules isolated from the hindgut and/or Malpighian tubules of a flea and proteins encoded by such nucleic acid molecules are referred to as flea HMT or HMT, nucleic acid molecules and proteins respectively.

5 HNC nucleic acid molecules and HMT nucleic acid molecules of the present invention are nucleic acid molecules that are primarily expressed in flea HNC tissues and HMT tissues respectively, but which may be expressed in cells derived from flea tissues other than HNC and HMT. HNC and HMT nucleic acid molecules and proteins of the present invention can be isolated from a flea or prepared recombinantly or synthetically. HMT  
10 and HNC nucleic acid molecules of the present invention can be RNA or DNA; examples of nucleic acid molecules include, but are not limited to, complementary DNA (cDNA) molecules, genomic DNA molecules, synthetic DNA molecules, DNA molecules which are specific tags for messenger RNA derived from HMT and HNC tissues, and corresponding mRNA molecules. As used herein, the phrases "HMT and/or HNC  
15 protein" and "HMT and HNC protein" refer to a protein expressed by a flea HMT tissue, by a flea HNC tissue, or by both flea HMT and HNC tissues. As used herein, the phrases "HMT and/or HNC nucleic acid molecule" and "HMT and HNC nucleic acid molecule" refer to a nucleic acid molecule that can be isolated from a HMT cDNA library, from a HNC cDNA library, or from both libraries, or a gene corresponding thereto.

20 The present invention provides for nucleic acid molecules containing partial or full-length coding regions that encode one or more of the following flea proteins: an allantoinase (ALN) protein, a chitin-binding protein (CBP) protein, a sodium/potassium

ATPase beta subunit (NKAB) protein, a ligand-gated chloride channel (LGIC) protein, an ANON/23DA (ANON) protein, a malvolio (MALV) protein, an odorant-binding protein-like (OS-D) protein, a N-methyl-D-aspartate receptor associated (NMDA) protein, a chemical sense related lipophilic ligand binding protein-like (CLBP) protein, a

5 Sodium/Hydrogen Transporter-like (NAH) protein, a Chloride Intracellular Channel-like (CLIC) protein, a Peritrophin-like (PL2) protein, a Peritrophin-like (PL3) protein, a Peritrophin-like (PL4) protein, a synaptic vesicle 2B-like (SVP) protein, a voltage-gated Chloride-like (VGCC) protein, an anoxia upregulated protein-like (AUP) protein, and a neuroendocrine specific 7B2-like (7B2) protein. Such nucleic acid molecules are referred

10 to as ALN nucleic acid molecules, CBP nucleic acid molecules, NKAB nucleic acid molecules, LGIC nucleic acid molecules, ANON nucleic acid molecules, MALV nucleic acid molecules, OS-D nucleic acid molecules, NMDA nucleic acid molecules, CLBP nucleic acid molecules, NAH nucleic acid molecules, CLIC nucleic acid molecules, PL2 nucleic acid molecules, PL3 nucleic acid molecules, PL4 nucleic acid molecules, SVP

15 nucleic acid molecules, VGCC nucleic acid molecules, AUP nucleic acid molecules, and 7B2 nucleic acid molecules respectively and are described herein in detail below.

Allantoinase is involved in the catalysis of the reaction converting allantoin to allantoic acid. This is a middle step in purine catabolism, which in insects results in the secretion of urea as the end product. The enzyme is located in the peroxisomes of the

20 liver and kidney in amphibians. There is no known mammalian homologue to allantoinase, as mammals secrete uric acid, a precursor to allantoin. As such, flea allantoinase represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

The function of chitin binding protein is largely unknown. A chitinase-like protein of *Bombyx mori* (GenBank accession # 1841851) is reported to have weak similarity with the chitin-binding domain of insect chitinases; however, it has no significant similarity to the catalytic regions of known chitinases, and therefore is not expected to have chitinase activity. The chitinase-like protein of *B. mori* is also similar to the peritrophin family of proteins located in the peritrophic matrix of insects. These proteins contain putative chitin-binding domains but have no other apparent homology to any known proteins. Without being bound by theory, it is believed that these proteins bind chitin and are a structural component of the peritrophic matrix. As such, flea chitin binding protein represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

Na<sup>+</sup>/K<sup>+</sup>ATPase is involved in the hydrolysis of ATP to power the transport of Na<sup>+</sup> out of and K<sup>+</sup> into cells. It is responsible for establishing the Na<sup>+</sup> gradient across plasma membranes, which is then used by cells for a number of functions including sugar and amino acid transport, diuresis and nerve cell signaling. The Na<sup>+</sup>/K<sup>+</sup> ATPase pump is a trimer of a 100-kilodalton (kDa) alpha (α) subunit, a 40-kDa beta (β) subunit, and a 6-kDa gamma (γ) subunit. Most insects express three isotypes of the β subunit, each being expressed in a tissue and cell-type dependent manner. The α subunit has 8 transmembrane domains whereas the β and γ subunits have just one. The α subunit mediates ATPase and ion transporting activities and together with the γ subunit comprises the site for cardiac glycoside (ouabain) binding. The β subunit is required for detectable pump activity, and is thought to have roles in stability, localization, and

determining cation specificity. As such, a flea NKAB protein of the present invention represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

Ligand-gated ion channel family proteins have been shown to transmit neural signals in response to binding neurotransmitters such as GABA, glycine, and glutamate. GABA and glycine receptors transmit inhibitory signals whereas glutamate receptors transmit excitatory signals. This family of proteins is the target for many drugs affecting neural signaling, and also for several families of insecticides including cyclodienes, pyrethroids, and phenyl pyrazoles. Northern blot analysis indicates that the mRNA corresponding to a LGIC nucleic acid molecule of the present invention is only expressed in HMT tissue, which suggests a role in the regulation or mediation of diuresis. Without being bound by theory, assuming protein expression correlates with the mRNA expression, flea LGIC may represent the first of this family of receptors shown to be exclusively expressed in renal tissue. Sequence analysis shows that a flea LGIC protein is distinct from other subfamilies of ligand-gated ion channels, and thus may represent a new subfamily. As such, a flea LGIC protein of the present invention represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

The function of ANON/23DA protein largely unknown. The ANON/23DA gene is reported to be linked to the MAD gene in *Drosophila*, though it is not known if ANON/23DA and MAD are functionally related. ANON/23DA may also have functional similarity to human probable membrane receptor protein pHPS1-2, which is similar to rhodopsin/beta-adrenergic receptor which plays an important role in kidney function. As such, a flea ANON/23DA protein of the present invention represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

*Drosophila malvolio* shows high sequence homology to mammalian natural resistance associated proteins (NRAMPs) and to yeast Smf1, which are proteins that transport divalent cations, specifically  $Mn^{++}$ ,  $Zn^{++}$ , and  $Fe^{++}$ . NRAMPs have also been shown be similar to ATPase transporters and use ATP as an energy source. There are two  
5 types of NRAMP proteins, NRAMP1 and NRAMP2. NRAMP1 is expressed exclusively on macrophages and is responsible for preventing intracellular replication of microbes. NRAMP2 is expressed in several cell and tissue types, including mouse intestinal epithelia. Flea malvolio proteins of the present invention appear to be most similar to NRAMP1. As such, a flea malvolio protein of the present invention represents a novel  
10 target for anti-flea vaccines and chemotherapeutic drugs.

The function of OS-D proteins is largely unknown. An OS-D nucleic acid molecule isolated from a *Drosophila melanogaster* antenna cDNA library encodes a protein that shares features common to vertebrate odorant-binding proteins, but has a primary structure unlike odorant-binding proteins. The encoded protein is also  
15 homologous to a family of soluble chemosensory proteins from the chemosensory organ of the desert locust, *Schistocerca gregaria*. As such, a flea OS-D protein of the present invention represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

NMDA receptors are a subtype of glutamate-gated ion channels. All glutamate-gated ion channels transmit  $Na^{+}$  and  $K^{+}$  when stimulated, resulting in a depolarization of  
20 the membrane potential. NMDA receptors also transport  $Ca^{++}$  into cells upon stimulation, which distinguishes NMDA receptors from the other glutamate-gated ion channels. NMDA receptors play an important role in glutamate excitotoxicity, which has been linked to a number of neurodegenerative disorders such as focal cerebral ischemia



(stroke), Parkinson's disease, Huntington's chorea, Alzheimer's disease, schizophrenia and epilepsy. It is thought that the  $\text{Ca}^{++}$  influx in open NMDA channels is the mediator for these diseases, since the increase in intracellular  $\text{Ca}^{++}$  concentration leads to the induction of metabolic changes in the cell, including the activation of  $\text{Ca}^{++}$  dependent proteases and production of free-oxygen radicals. As such, a flea NMDA protein of the present invention represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

CLBP proteins of the present invention appear to fall into the family of PBP/GOBP proteins (pheromone binding protein/general odorant binding protein) based on sequence homology with members of this family (30% identity with PBPRP-2, pheromone binding protein related protein #2 of *Drosophila melanogaster*, and approximately the same identity with CSRLBP, chemical sense related lipophilic ligand binding protein of *Phormia regina*). Without being bound by theory, it is believed that these proteins are involved in the perception of odors or pheromones, such as the ability to sense the presence of a host or mate. As such, a flea CLBP protein of the present invention represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

Peritrophins, including flea PL2, PL3 and PL4 proteins of the present invention, are a family of putative chitin-binding proteins that comprise a structural component of the peritrophic matrix, an acellular membrane composed of proteins and sugars, most commonly chitin which forms a barrier between the contents of an ingested meal and the gut epithelia. Peritrophin-like proteins have also been shown to be present in the trachea of *Drosophila* embryos, indicating that such proteins may have additional roles outside the midgut. The function of the peritrophin-like proteins in adult fleas is not clear, since

adult fleas do not produce a peritrophic matrix in the gut. Peritrophins have been investigated as targets for immunological control of hematophagous insects including the sheep blowfly, *Lucilia cuprina*. It has been shown in this insect that ingestion of antibodies against peritrophins inhibits the growth of larvae and can result in increased larval mortality. It has also been shown that the ingestion of antibodies against peritrophins reduces the permeability of the peritrophic matrix in *L. cuprina* larvae. This in turn may inhibit the movement of digested food across the peritrophic matrix to the gut epithelium, resulting in starvation. As such, a flea peritrophin of the present invention represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

10 In general, voltage-gated chloride channels (VGCC) maintain resting epithelial and neural membrane potentials and prevent hyperexcitability (sustained contraction) in muscle cells. In *Drosophila* Malpighian tubules, the diuretic hormone leukokinin has been shown to stimulate voltage-gated chloride channels in the stellate cells by increasing intracellular calcium levels. The flea VGCC protein sequence of the present invention  
15 contains an EF-hand calcium binding motif, indicating potential regulation by calcium ions, and thus a possible link to leukokinins and diuresis. Chloride channels are critical for diuresis since chloride is the primary anion driving diuresis and is required to help neutralize the sodium and potassium cations that are secreted into the lumen in response to diuretic peptide. The mRNA for the VGCC of the present invention has been shown to  
20 be HMT-specific in adult fleas, indicating a potential role in diuresis. As such, a flea VGCC of the present invention represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

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The CLIC family of chloride channels are voltage-gated chloride channels that are expressed on a variety of vesicles and are thought to act in concert with the V-ATPase pump to regulate the pH of the vesicle interior. Members of the CLIC family have also been shown to be expressed on the plasma membrane, again, in association with the V-ATPase pump. In humans, a homologous protein has been shown to be expressed on the plasma membrane in epithelial tissues, suggesting a possible role in transepithelial chloride transport and in cows, an antibody against a homologous channel has been shown to inhibit all chloride conductance in kidney microsomes. If the CLIC gene product is indeed involved in transepithelial chloride transport in HMT tissues, it likely plays a critical role in mediating diuresis. As such, a flea CLIC of the present invention represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

The NAH exchanger uses the proton gradient in the lumen of the Malpighian tubule to power the transport of sodium ions across the apical membrane into the lumen. The transport of sodium ions across the Malpighian tubule epithelia is induced by diuretic peptide and is a critical step in the induction of diuresis. The Northern blot analysis described herein indicates that NAH mRNA is upregulated within 15 minutes of feeding in adults, which is consistent with a molecule having a role in diuresis. In many insects, sodium has been shown to be the principle ion driving diuresis. The NAH exchanger has been shown to be located on the apical membrane in the Malpighian tubules, but may also be located in the hindgut and rectum. If located in the hindgut and rectum, it could be accessible to antibody attack on either the basolateral or apical membranes. As such, a flea NAH of the present invention represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

SVP proteins have structural and sequence conservation with a bacterial family of proton co-transporters, with the mammalian proton/glucose transporter, and with organic ion transporters. SVP has 12 putative transmembrane regions that arise from an internal duplication. In mammals, it is located on neural and endocrine vesicles and is thought to function in the uptake of neurotransmitters into vesicles utilizing the proton gradient. Neurotransmitters in turn regulate the activity the ion channels on these membranes. In the Malpighian tubules, the activity of the ion channels determines the rate of diuresis, or fluid secretion from the hemolymph into the lumen. Thus, inhibiting the transport of neurotransmitters in the HMT tissues may have significant effects on the functions of these tissues. As such, a flea SVP of the present invention represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

The function of flea AUP proteins is largely unknown. *C. felis* AUP shares some homology to *Drosophila melanogaster* anoxia-regulated gene product *fau*. The *Drosophila melanogaster* *fau* gene has no homology to previously described database entries, but localizes to laminar and cortical neurons of the *Drosophila* CNS by in situ hybridization, and plays an important role in response to O<sub>2</sub> deprivation as measured by impaired recovery time of transgenic flies over-expressing *fau* to anoxia. As such, a flea AUP of the present invention represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

A flea 7B2 protein has some BLAST homology to the neuroendocrine protein 7B2 from various organisms, including *Drosophila*, *C. elegans*, the pond snail *Lymnaea stagnalis*, and humans. 7B2 has been implicated in activation of prohormone convertase 2 (PC2) an important neuroendocrine precursor processing endoprotease. Additionally,

7B2 was found to be critical in islet hormone processing in mice using null mutants which displayed hypoglycemia, hyperproinsulinemia and hypoglucagonemia. As such, a flea 7B2 of the present invention represents a novel target for anti-flea vaccines and chemotherapeutic drugs.

5 Flea allantoinase nucleic acid molecules of known length isolated from *C. felis* are denoted "nCfALN<sub>#</sub>", for example nCfALN<sub>2057</sub>, wherein "#" refers to the number of nucleotides in that molecule, and allantoinase proteins of known length are denoted "PCfALN<sub>#</sub>" (for example PCfALN<sub>384</sub>) wherein "#" refers to the number of amino acid residues in that molecule. Similarly, *C. felis* CBP nucleic acid molecules and proteins of known length are denoted "nCfCBP<sub>#</sub>" and "PCfCBP<sub>#</sub>", respectively; *C. felis* NKAB nucleic acid molecules and proteins of known length are denoted "nCfNKAB<sub>#</sub>" and "PCfNKAB<sub>#</sub>", respectively; *C. felis* LGIC nucleic acid molecules and proteins of known length are denoted "nCfLGIC<sub>#</sub>" and "PCfLGIC<sub>#</sub>", respectively; *C. felis* ANON nucleic acid molecules and proteins of known length are denoted "nCfANON<sub>#</sub>" and "PCfANON<sub>#</sub>", respectively; *C. felis* MALV nucleic acid molecules and proteins of known length are denoted "nCfMALV<sub>#</sub>" and "PCfMALV<sub>#</sub>" respectively; *C. felis* OS-D nucleic acid molecules and proteins of known length are denoted "nCfOSD<sub>#</sub>" and "PCfOSD<sub>#</sub>" respectively; *C. felis* NMDA nucleic acid molecules and proteins of known length are denoted "nCfNMDA<sub>#</sub>" and "PCfNMDA<sub>#</sub>" respectively; *C. felis* CLBP nucleic acid molecules and proteins of known length are denoted "nCfCLBP<sub>#</sub>" and "PCfCLBP<sub>#</sub>" respectively; *C. felis* NAH nucleic acid molecules and proteins of known length are denoted "nCfNAH<sub>#</sub>" and "PCfNAH<sub>#</sub>" respectively; *C. felis* CLIC nucleic acid molecules

and proteins of known length are denoted "nCfCLIC<sub>#</sub>" and "PCfCLIC<sub>#</sub>" respectively, *C. felis* PL2 nucleic acid molecules and proteins of known length are denoted "nCfPL2<sub>#</sub>" and "PCfPL2<sub>#</sub>" respectively, *C. felis* PL3 nucleic acid molecules and proteins of known length are denoted "nCfPL3<sub>#</sub>" and "PCfPL3<sub>#</sub>" respectively, *C. felis* PL4 nucleic acid molecules and proteins of known length are denoted "nCfPL4<sub>#</sub>" and "PCfPL4<sub>#</sub>" respectively, *C. felis* SVP nucleic acid molecules and proteins of known length are denoted "nCfSVP<sub>#</sub>" and "PCfSVP<sub>#</sub>" respectively, *C. felis* VGCC nucleic acid molecules and proteins of known length are denoted "nCfVGCC<sub>#</sub>" and "PCfVGCC<sub>#</sub>" respectively, *C. felis* AUP nucleic acid molecules and proteins of known length are denoted "nCfAUP<sub>f#</sub>" and "PCfAUP<sub>#</sub>" respectively, and *C. felis* 7B2 nucleic acid molecules and proteins of known length are denoted "nCf7B2<sub>#</sub>" and "PCf7B2<sub>#</sub>" respectively.

The present invention also provides for HMT and HNC DNA molecules that are specific tags for messenger RNA molecules derived from HMT and HNC tissues. Such DNA molecules can correspond to an entire or partial sequence of a messenger RNA, and therefore, a DNA molecule corresponding to such a messenger RNA molecule (i.e. a cDNA molecule), can encode a full-length or partial-length protein. A nucleic acid molecule encoding a partial-length protein can be used directly as a probe or indirectly to generate primers to identify and/or isolate a cDNA nucleic acid molecule encoding a corresponding, or structurally related, full-length protein. Such a partial cDNA nucleic acid molecule can also be used in a similar manner to identify a genomic nucleic acid molecule, such as a nucleic acid molecule that contains the complete gene including regulatory regions, exons and introns. Methods for using partial HMT and HNC cDNA

molecules and sequences to isolate full-length transcripts and corresponding cDNA molecules are described in the examples herein below.

The proteins and nucleic acid molecules of the present invention can be obtained from their natural source, or can be produced using, for example, recombinant nucleic acid technology or chemical synthesis. Also included in the present invention is the use of these proteins and nucleic acid molecules as well as antibodies and inhibitory compounds thereto as therapeutic compositions to protect animals from flea infestation as well as in other applications, such as those disclosed below.

Flea HMT and HNC proteins and nucleic acid molecules of the present invention have utility because they represent novel targets for anti-arthropod vaccines and chemotherapeutic drugs. The products and processes of the present invention are advantageous because they enable the inhibition of arthropod development, metamorphosis, feeding, digestion and/or reproduction processes that involve HMT and/or HNC proteins.

The head and nerve cord of the flea, including antennae, brain, corpora cardiacum, corpora allata, and subesophageal and abdominal ganglion tissues are of interest as such tissues are highly enriched for transcripts that encode neuronal and endocrine targets, as well as targets involved in chemosensory and mechanosensory reception. By sequencing cDNA fragments from a library enriched in flea head and nerve cord nucleic acid sequences (referred to herein as HNC nucleic acid sequences), genes, and their respective full-length coding regions, integrally involved with flea neuronal and endocrine function are identified. Once identified, these genes can be further characterized and specific

interference strategies are designed. As such, flea HNC proteins and nucleic acid molecules of the present invention have utility because they represent novel targets for anti-arthropod vaccines and chemotherapeutic drugs.

Blood-feeding insects such as fleas ingest large quantities of blood relative to their body weight and, as such, are adapted to reduce the volume of the ingested blood meal through the rapid elimination of water. In addition, the concentrations of sodium, potassium, and chloride ions in the blood meal are greater than in the hemolymph of fleas, necessitating the excretion of excessive amounts of these ions. The active transport of these ions from the hemolymph into the lumens of the Malpighian tubules and the hindgut drives the passive transport of water and other hemolymph contents into these organs as well. While passing through these organs, waste products from the hemolymph are excreted and needed nutrients, water, and salts are reabsorbed. As such, interfering with these essential processes is an important strategy for developing a product for controlling flea populations. By sequencing cDNA fragments from a library enriched in hindgut and Malpighian tubule nucleic acid sequences (referred to herein as HMT nucleic acid sequences), genes integrally involved with these processes, and their respective full-length coding regions, are identified. Once identified, these genes are further characterized and specific interference strategies can be designed. As such, flea HMT proteins and nucleic acid molecules of the present invention have utility because they represent novel targets for anti-arthropod vaccines and chemotherapeutic drugs.

One embodiment of the present invention is an isolated protein that includes a flea HMT and/or HNC protein. It is to be noted that the term "a" or "an" entity refers to one



or more of that entity; for example, a protein, a nucleic acid molecule, an antibody and a therapeutic composition refers to "one or more" or "at least one" protein, nucleic acid molecule, antibody and therapeutic composition respectively. As such, the terms "a" (or "an"), "one or more" and "at least one" can be used interchangeably herein. It is also to be  
 5 noted that the terms "comprising", "including", and "having" can be used interchangeably. According to the present invention, an isolated, or biologically pure, protein, is a protein that has been removed from its natural milieu. As such, "isolated" and "biologically pure" do not necessarily reflect the extent to which the protein has been purified. An isolated protein of the present invention can be obtained from its natural source, can be  
 10 produced using recombinant DNA technology, or can be produced by chemical synthesis.

As used herein, isolated flea HMT and/or HNC proteins of the present invention can be full-length proteins or any homologue of such proteins. An isolated protein of the present invention, including a homologue, can be identified in a straight-forward manner by the protein's ability to elicit an immune response against a flea HMT and/or HNC  
 15 protein or by the protein's HMT and/or HNC activity. Examples of flea HMT and HNC homologue proteins include flea HMT and HNC proteins in which amino acids have been deleted (e.g., a truncated version of the protein, such as a peptide), inserted, inverted, substituted and/or derivatized (e.g., by glycosylation, phosphorylation, acetylation, myristoylation, prenylation, palmitoylation, amidation and/or addition of  
 20 glycerophosphatidyl inositol) such that the homologue includes at least one epitope capable of eliciting an immune response against a flea HMT or HNC protein, and/or of binding to an antibody directed against a flea HMT or HNC protein. That is, when the

homologue is administered to an animal as an immunogen, using techniques known to those skilled in the art, the animal will produce an immune response against at least one epitope of a natural flea HMT or HNC protein. The ability of a protein to effect an immune response can be measured using techniques known to those skilled in the art. As used herein, the term "epitope" refers to the smallest portion of a protein or other antigen capable of selectively binding to the antigen binding site of an antibody or a T cell receptor. It is well accepted by those skilled in the art that the minimal size of a protein epitope is about four to six amino acids. As is appreciated by those skilled in the art, an epitope can include amino acids that naturally are contiguous to each other as well as amino acids that, due to the tertiary structure of the natural protein, are in sufficiently close proximity to form an epitope. According to the present invention, an epitope includes a portion of a protein comprising at least about 4 amino acids, at least about 5 amino acids, at least about 6 amino acids, at least about 10 amino acids, at least about 15 amino acids, at least about 20 amino acids, at least about 25 amino acids, at least about 30 amino acids, at least about 35 amino acids, at least about 40 amino acids or at least about 50 amino acids in length.

In one embodiment of the present invention a flea homologue protein has HMT or HNC activity, i.e. the homologue exhibits an activity similar to its natural counterpart. Examples of such activities are disclosed herein; e.g., all. Methods to detect and measure such activities are known to those skilled in the art. Examples of such activities are disclosed herein; e.g. allantoinase, chitin-binding protein, sodium/potassium ATPase, ligand-gated chloride channel, ANON/23DA, malvolio, odorant binding protein-like

protein, N-methyl-D-aspartate receptor associated protein, chemical sense related lipophilic ligand binding protein, Sodium/Hydrogen Transporter-like protein, a Chloride Intracellular Channel-like protein, aPeritrophin-like protein, aPeritrophin-like protein, aPeritrophin-like protein, a synaptic vesicle 2B-like protein, a voltage-gated Chloride-like protein, an anoxia upregulated protein-like protein, and a neuroendocrine specific 7B2-like protein.

Flea HMT and/or HNC homologue proteins can be the result of natural allelic variation or natural mutation. Flea HMT and/or HNC protein homologues of the present invention can also be produced using techniques known in the art including, but not limited to, direct modifications to the protein or modifications to the gene encoding the protein using, for example, classic or recombinant DNA techniques to effect random or targeted mutagenesis.

Flea HMT and HNC proteins of the present invention are encoded by flea HMT and HNC nucleic acid molecules, respectively. As used herein, flea HMT and HNC nucleic acid molecules include nucleic acid sequences related to natural flea HMT and HNC genes, and, preferably, to *Ctenocephalides felis* HMT and HNC genes. As used herein, flea HMT and HNC genes include all regions such as regulatory regions that control production of flea HMT and HNC proteins encoded by such genes (such as, but not limited to, transcription, translation or post-translation control regions) as well as the coding region itself, and any introns or non-translated coding regions. As used herein, a nucleic acid molecule that "includes" or "comprises" a sequence may include that sequence in one contiguous array, or may include the sequence as fragmented exons such

as is often found for a flea gene. As used herein, the term "coding region" refers to a continuous linear array of nucleotides that translates into a protein. A full-length coding region is that coding region that is translated into a full-length, i.e., a complete protein as would be initially translated in its natural milieu, prior to any post-translational

5 modifications.

One embodiment of the present invention is a *C. felis* ALN gene that includes the nucleic acid sequence SEQ ID NO:1 and/or SEQ ID NO:4, a *C. felis* CBP gene that includes the nucleic acid sequence SEQ ID NO:7 and/or SEQ ID NO:10, a *C. felis* NKAB gene that includes the nucleic acid sequence SEQ ID NO:13 and/or SEQ ID NO:16, a *C.*

10 *felis* LGIC gene that includes the nucleic acid sequence SEQ ID NO:19, SEQ ID NO:22, SEQ ID NO:1861, and/or SEQ ID NO:1864, a *C. felis* ANON gene that includes the nucleic acid sequence SEQ ID NO:25 and/or SEQ ID NO:28, a *C. felis* MALV gene that includes the nucleic acid sequence SEQ ID NO:31 and/or SEQ ID NO:34, a *C. felis* OS-D gene that includes the nucleic acid sequence SEQ ID NO:37 and/or SEQ ID NO:40, a *C.*

15 *felis* NMDA gene that includes the nucleic acid sequence SEQ ID NO: 43 and/or SEQ ID NO:46, a *C. felis* CLBP gene that includes the nucleic acid sequence SEQ ID NO:153, SEQ ID NO:156, SEQ ID NO:159, SEQ ID NO:162, SEQ ID NO:165, and/or SEQ ID NO:168, a *C. felis* NAH gene that includes the nucleic acid sequence SEQ ID NO:1867 and/or SEQ ID NO:1870, a *C. felis* CLIC gene that includes the nucleic acid sequence

20 SEQ ID NO:1872 and/or SEQ ID NO:1875, a *C. felis* PL2 gene that includes the nucleic acid sequence SEQ ID NO:1877, SEQ ID NO:1878, SEQ ID NO:1880, SEQ ID NO:1882 and/or SEQ ID NO:1885, a *C. felis* PL3 gene that includes the nucleic acid sequence SEQ

ID NO:1887 and/or SEQ ID NO:1890, a *C. felis* PL4 gene that includes the nucleic acid  
 sequence SEQ ID NO:1896 and/or SEQ ID NO:1899, a *C. felis* SVP gene that includes  
 the nucleic acid sequence SEQ ID NO:1901 and/or SEQ ID NO:1904, a *C. felis* VGCC  
 gene that includes the nucleic acid sequence SEQ ID NO:1914 and/or SEQ ID NO:1917,  
 5 a *C. felis* AUP gene that includes the nucleic acid sequence SEQ ID NO:1919 and/or SEQ  
 ID NO:1922, a *C. felis* 7B2 gene that includes the nucleic acid sequence SEQ ID  
 NO:1924 and/or SEQ ID NO:1927, a *C. felis* gene that includes a nucleic acid sequence  
 of Table I, Table II, Table III and/or Table IV; as well as the complements of any of these  
 nucleic acid sequences. These nucleic acid sequences are further described herein. For  
 10 example, nucleic acid sequence SEQ ID NO:1 represents the deduced sequence of the  
 coding strand of a *C. felis* cDNA denoted herein as *C. felis* ALN nucleic acid molecule  
 nCfALN<sub>2057</sub>, the production of which is disclosed in the Examples. Nucleic acid  
 molecule SEQ ID NO:1 comprises an apparently full-length coding region. The  
 complement of SEQ ID NO:1 (represented herein by SEQ ID NO:3) refers to the nucleic  
 15 acid sequence of the strand fully complementary to the strand having SEQ ID NO:1,  
 which can easily be determined by those skilled in the art. Likewise, a nucleic acid  
 sequence complement of any nucleic acid sequence of the present invention refers to the  
 nucleic acid sequence of the nucleic acid strand that is fully complementary to (i.e., can  
 form a complete double helix with) the strand for which the sequence is cited. For  
 20 example, the complements of SEQ ID NOS: 4, 7, 10, 13, 16, 19, 22, 25, 28, 31, 34, 37,  
 40, 43, 46, 153, 156, 159, 162, 165, and 168 are SEQ ID NOS: 6, 9, 12, 15, 18, 21, 24, 27,  
 30, 33, 36, 39, 42, 45, 48, 155, 158, 161, 164, 167, and 170, respectively. It should be

noted that since nucleic acid sequencing technology is not entirely error-free, SEQ ID NO:1 (as well as other nucleic acid and protein sequences presented herein) represents an apparent nucleic acid sequence of the nucleic acid molecule encoding an ALN protein of the present invention.

5 Translation of SEQ ID NO:1, the coding strand of nCfALN<sub>2057</sub>, as well as translation of SEQ ID NO:4, the coding strand of nCfALN<sub>1152</sub>, which represents the coding region of SEQ ID NO:1, each yields a protein of about 384 amino acids, denoted herein as PCfALN<sub>384</sub>, the amino acid sequence of which is presented in SEQ ID NO:2, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID  
10 NO:4.

Translation of SEQ ID NO:7, the coding strand of nCfCBP<sub>1128</sub>, as well as translation of SEQ ID NO:10, the coding strand of nCfCBP<sub>1128</sub>, which represents the coding region of SEQ ID NO:7, each yields a protein of about 272 amino acids, denoted herein as PCfCBP<sub>272</sub>, the amino acid sequence of which is presented in SEQ ID NO:8,  
15 assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:10.

Translation of SEQ ID NO:13, the coding strand of nCfNKAB<sub>1714</sub>, as well as translation of SEQ ID NO:16, the coding strand of nCfNKAB<sub>978</sub>, which represents the coding region of SEQ ID NO:13, each yields a protein of about 326 amino acids, denoted  
20 herein as PCfNKAB<sub>326</sub>, the amino acid sequence of which is presented in SEQ ID NO:14, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:16.

Translation of SEQ ID NO:19, the coding strand of nCfLGIC<sub>2240</sub>, as well as translation of SEQ ID NO:22, the coding strand of nCfLGIC<sub>1707</sub>, which represents the coding region of SEQ ID NO:19, each yields a protein of about 569 amino acids, denoted herein as PCfLGIC<sub>569</sub>, the amino acid sequence of which is presented in SEQ ID NO:20,  
 5 assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:22.

Translation of SEQ ID NO:25, the coding strand of nCfANON<sub>1429</sub>, as well as translation of SEQ ID NO:28, the coding strand of nCfANON<sub>1194</sub>, which represents the coding region of SEQ ID NO:25, each yields a protein of about 398 amino acids, denoted  
 10 herein as PCfANON<sub>398</sub>, the amino acid sequence of which is presented in SEQ ID NO:26, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:28.

Translation of SEQ ID NO:31, the coding strand of nCfMALV<sub>765</sub>, as well as translation of SEQ ID NO:34, the coding strand of nCfMALV<sub>762</sub>, which represents the  
 15 coding region of SEQ ID NO:31, each yields a protein of about 327 amino acids, denoted herein as PCfMALV<sub>254</sub>, the amino acid sequence of which is presented in SEQ ID NO:32, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:34.

Translation of SEQ ID NO:37, the coding strand of nCfOSD<sub>604</sub>, as well as  
 20 translation of SEQ ID NO:40, the coding strand of nCfOSD<sub>405</sub>, which represents the coding region of SEQ ID NO:37, each yields a protein of about 135 amino acids, denoted herein as PCfOSD<sub>135</sub>, the amino acid sequence of which is presented in SEQ ID NO:38,

assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:40.

Translation of SEQ ID NO:43, the coding strand of nNMDA<sub>1227</sub>, as well as translation of SEQ ID NO:46, the coding strand of nCfNMDA<sub>738</sub>, which represents the coding region of SEQ ID NO:43, each yields a protein of about 246 amino acids, denoted herein as PCfNMDA<sub>246</sub>, the amino acid sequence of which is presented in SEQ ID NO:44, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:46.

Translation of SEQ ID NO:153, the coding strand of nCfCLBP1A<sub>633</sub>, as well as translation of SEQ ID NO:156, the coding strand of nCfCLBP1A<sub>441</sub>, which represents the coding region of SEQ ID NO:153, each yields a protein of about 147 amino acids, denoted herein as PCfCLBP<sub>147</sub>, the amino acid sequence of which is presented in SEQ ID NO:154, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:156.

Translation of SEQ ID NO:162, the coding strand of nCfCLBP2A<sub>631</sub>, as well as translation of SEQ ID NO:165, the coding strand of nCfCLBP2A<sub>441</sub>, which represents the coding region of SEQ ID NO:162, each yields a protein of about 147 amino acids, denoted herein as PCfCLBP2A<sub>147</sub>, the amino acid sequence of which is presented in SEQ ID NO:163, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:165.

Translation of SEQ ID NO:1861, the coding strand of nCfLGIC<sub>2739</sub>, as well as translation of SEQ ID NO:1864, the coding strand of nCfLGIC<sub>2016</sub>, which represents the



coding region of SEQ ID NO:1861, each yields a protein of about 672 amino acids, denoted herein as PCfLGIC<sub>672</sub>, the amino acid sequence of which is presented in SEQ ID NO:1862, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:1864.

5 Translation of SEQ ID NO:1867, the coding strand of nCfNAH<sub>2080</sub>, as well as translation of SEQ ID NO:1870, the coding strand of nCfNAH<sub>1824</sub>, which represents the coding region of SEQ ID NO:1867, each yields a protein of about 608 amino acids, denoted herein as PCfNAH<sub>608</sub>, the amino acid sequence of which is presented in SEQ ID NO:1868, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of  
10 SEQ ID NO:1870.

Translation of SEQ ID NO:1872, the coding strand of nCfCLIC<sub>2283</sub>, as well as translation of SEQ ID NO:1875, the coding strand of nCfCLIC<sub>786</sub>, which represents the coding region of SEQ ID NO:1872, each yields a protein of about 262 amino acids, denoted herein as PCfCLIC<sub>262</sub>, the amino acid sequence of which is presented in SEQ ID  
15 NO:1873, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:1875.

Translation of SEQ ID NO:1882, the coding strand of nCfPL2<sub>1477</sub>, as well as translation of SEQ ID NO:1885, the coding strand of nCfPL2<sub>1359</sub>, which represents the coding region of SEQ ID NO:1882, each yields a protein of about 453 amino acids,  
20 denoted herein as PCfPL2<sub>453</sub>, the amino acid sequence of which is presented in SEQ ID NO:1883, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:1885.

Translation of SEQ ID NO:1887, the coding strand of nCfPL3<sub>406</sub>, as well as translation of SEQ ID NO:1890, the coding strand of nCfPL3<sub>243</sub>, which represents the coding region of SEQ ID NO:1887, each yields a protein of about 81 amino acids, denoted herein as PCfPL3<sub>81</sub>, the amino acid sequence of which is presented in SEQ ID

5 NO:1888, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:1890.

Translation of SEQ ID NO:1896, the coding strand of nCfPL4<sub>1062</sub>, as well as translation of SEQ ID NO:1899, the coding strand of nCfPL4<sub>855</sub>, which represents the coding region of SEQ ID NO:1896, each yields a protein of about 285 amino acids,

10 denoted herein as PCfPL4<sub>285</sub>, the amino acid sequence of which is presented in SEQ ID NO:1897, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:1899.

Translation of SEQ ID NO:1901, the coding strand of nCfSVP<sub>1875</sub>, as well as translation of SEQ ID NO:1904, the coding strand of nCfSVP<sub>1590</sub>, which represents the

15 coding region of SEQ ID NO:1901, each yields a protein of about 530 amino acids, denoted herein as PCfSVP<sub>530</sub>, the amino acid sequence of which is presented in SEQ ID NO:1902, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:1904.

Translation of SEQ ID NO:1914, the coding strand of nCfVGCC<sub>3126</sub>, as well as

20 translation of SEQ ID NO:1917, the coding strand of nCfVGCC<sub>2553</sub>, which represents the coding region of SEQ ID NO:1914, each yields a protein of about 851 amino acids, denoted herein as PCfVGCC<sub>851</sub>, the amino acid sequence of which is presented in SEQ ID

NO:1915, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:1917.

Translation of SEQ ID NO:1919, the coding strand of nCfAUP<sub>1181</sub>, as well as translation of SEQ ID NO:1922, the coding strand of nCfAUP<sub>306</sub>, which represents the coding region of SEQ ID NO:1919, each yields a protein of about 102 amino acids, denoted herein as PCfAUP<sub>102</sub>, the amino acid sequence of which is presented in SEQ ID NO:1920, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:1922.

Translation of SEQ ID NO:1924, the coding strand of nCf7B2<sub>2161</sub>, as well as translation of SEQ ID NO:1927, the coding strand of nCf7B2<sub>801</sub>, which represents the coding region of SEQ ID NO:1924, each yields a protein of about 267 amino acids, denoted herein as PCf7B2<sub>267</sub>, the amino acid sequence of which is presented in SEQ ID NO:1925, assuming a first in-frame codon extending from nucleotide 1 to nucleotide 3 of SEQ ID NO:1927.

Table I represents a variety of flea HNC nucleic acid molecules of the present invention. Also cited in Table I are nucleic acid molecules from other organisms which share the closest sequence identity with the cited HNC sequences of the present invention, as determined by submitting each HNC sequence for a search through the National Center for Biotechnology Information (NCBI), National Library of Medicine, National Institute of Health, Baltimore, MD, using the BLAST network. This database includes SwissProt + PIR + SPupdate + GenPept + GPUpdate + PDB databases. The search was conducted using the xBLAST function using default parameters.

TABLE I

SEQ ID NO	Name	Genbank Homology	Organism
63	2096-46	ATPase 6	<i>D. melanogaster</i>
64	2098-25	ATP synthase delta chain	<i>Sus scrofa</i>
65	2098-34	F1-ATPase epsilon-subunit	<i>Ipomoea batatas</i>
66	2110-19	ATP synthase beta subunit	<i>Drosophila pseudoobscura</i>
67	2113-15	ATP synthase delta chain,	<i>Sus scrofa</i>
68	2180-31	ATP synthase alpha subunit precursor	<i>Rattus rattus</i>
69	2224-50	oligomycin sensitivity conferring protein	<i>D. melanogaster</i>
70	2116-51	cysteine dioxygenase	<i>Homo sapiens</i>
71	2116-55	pyrroline-5-carboxylate dehydrogenase (P5CDh)	<i>Homo sapiens</i>
72	2124-17	AMP deaminase	<i>Homo sapiens</i>
73	2138-38	ubiquitin	<i>Mus musculus</i>
74	2184-59	manganese superoxide dismutase	<i>Homo sapiens</i>
75	2096-24	muscle LIM protein 1	<i>D. melanogaster</i>
76	2140-53	F25H5.1a	<i>C. elegans</i>
77	2176-41	Frazzled	<i>D. melanogaster</i>
78	2223-11	LIM domain-containing protein	<i>C. elegans</i>
79	2223-53	deleted in split hand/split foot 1 (DSS1)	<i>Homo sapiens</i>
80	2225-28	stranded-at-second	<i>D. melanogaster</i>
81	2099-61	histone H3	<i>Spisula solidissima</i>
82	2114-21	STE12	<i>S. cerevisiae</i>
83	2117-4	Rad51 homolog	<i>Bombyx mori</i>
84	2138-46	heat shock protein p27	<i>D. immitis</i>
85	2182-37	heat shock protein 70	<i>D. immitis</i>
86	2211-32	BTB-II protein domain gene	<i>D. melanogaster</i>
87	2223-7	heat shock protein	<i>D. melanogaster</i>
88	2224-17	heat shock protein 86	<i>Homo sapiens</i>
89	2225-16	POU domain protein	<i>D. melanogaster</i>
90	2225-18	nucleolin	<i>Xenopus laevis</i>
91	2212-85	thyroid hormone receptor-associated protein complex component TRAP220	<i>Homo sapiens</i>
92	2211-21	T03D8.3	<i>C. elegans</i>
93	2223-67	hepatoma derived growth factor (HDGF)	<i>Mus musculus</i>
94	2225-61	tyrosine hydroxylase type 1 (neuronal form)	<i>D. melanogaster</i>
95	2097-7	sarco/endoplasmic reticulum-type Ca-2+-ATPase	<i>D. melanogaster</i>
96	2098-27	calcium-transporting ATPase	<i>D. melanogaster</i>
97	2099-19	calcium channel alpha-1 subunit	<i>Aplysia californica</i>
98	2120-5	P-type voltage-gated calcium channel alpha 1 subunit homolog	<i>Homo sapiens</i>
99	2124-2	sarco/endoplasmic reticulum Ca2+-ATPase (SERCA)	<i>Procambarus clarkii</i>
100	2182-43	sulfonylurea receptor 2b	<i>Mus musculus</i>
101	2223-18	Sodium-Potassium-Chloride cotransporter	<i>D. melanogaster</i>
102	2223-63	sarco/endoplasmic reticulum-type Ca2(+)-ATPase	<i>D. melanogaster</i>

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Table I (cont'd)

SEQ ID NO.	Name	Genbank Homology	Organism
103	2224-13	similar to ABC transporters	<i>C. elegans</i>
104	2098-3	Camguk	<i>D. melanogaster</i>
105	2101-9	UNC-89	<i>C. elegans</i>
106	2132-31	arginine kinase	<i>Homarus gammarus</i>
107	2141-51	casein kinase-II beta	<i>Oryctolagus cuniculus</i>
108	2178-18	diacylglycerol kinase eta	<i>Cricetinae</i>
109	2180-32	retinoid- and fatty acid-binding glycoprotein	<i>D. melanogaster</i>
110	2137-23	vitellogenin	<i>Aedes aegypti</i>
111	2144-14	nuclear localization signal spot 1	<i>Mus musculus</i>
112	2212-13	putative n- terminal acetyltransferase	<i>S. cerevisiae</i>
113	2212-27	clathrin associated protein AP47	<i>Drosophila grimshawi</i>
114	2223-28	O1 chloroquine-resistance protein	<i>Plasmodium falciparans</i>
115	2224-14	vitellogenin	<i>Athalia rosae</i>
116	2224-15	antigen NY-CO-3	<i>Homo sapiens</i>
117	2225-24	carbonic anhydrase	<i>C. elegans</i>
118	2225-58	yk500f6.3	<i>C. elegans</i>
119	2225-76	unknown	<i>Homo sapiens</i>
120	2224-86	BmP109 (cerebroside sulfate activator protein family)	<i>Bombyx mori</i>
121	2225-23	intersectin	<i>Homo sapiens</i>
122	2170-16	chemical-sense-related lipophilic-ligand-binding protein	<i>Phormia regina</i>
123	2176-2	olfactory receptor protein 2.4	<i>Danio rerio</i>
124	2212-63	olfactory receptor	<i>Xenopus laevis</i>
125	2224-77	inner mitochondrial membrane translocase Tim23	<i>Homo sapiens</i>
126	2225-12	sodium-dependent multi-vitamin transporter	<i>Rattus norvegicus</i>
127	2225-42	ribophorin I	<i>Rattus norvegicus</i>
128	2101-59	phosphate carrier protein	<i>C. elegans</i>
129	2132-38	proteinase inhibitor	<i>Locusta migratoria</i>
130	2174-72	HE4 protein	<i>Homo sapiens</i>
131	2211-48	spermatogenic cell/sperm-associated Tat-binding homologue	<i>Rattus norvegicus</i>
132	2110-23	Gcap1 gene product	<i>Mus musculus</i>
133	2116-64	toll protein	<i>D. melanogaster</i>
134	2124-3	tuberin (TSC2) gene	<i>Homo sapiens</i>
135	2178-55	RAS-like protein	<i>Gallus gallus</i>
136	2223-35	Rho1 gene product	<i>D. melanogaster</i>
137	2224-82	paxillin	<i>Homo sapiens</i>
138	2225-44	adenylyl cyclase-associated protein (CAP)	<i>Homo sapiens</i>
139	2225-80	adenylate kinase	<i>Gallus gallus</i>
140	2110-52	hydroxyproline-rich glycoprotein	<i>Phaseolus vulgaris</i>
141	2115-49	mitogen inducible gene mig-2	<i>Homo sapiens</i>
142	2116-5	F52H3.5	<i>C. elegans</i>
143	2172-89	12D3 antigen	<i>Babesia bovis</i>
144	2178-20	frameshift	<i>P. falciparum</i>
145	2178-81	KIAA0066	<i>Homo sapiens</i>

Table I (cont'd)

SEQ ID NO:	Name	Genbank Homology	Organism
146	2182-16	Y57G11C.4	<i>C. elegans</i>
147	2182-53	C16C10.5	<i>C. elegans</i>
148	2211-8	Unknown	<i>Homo sapiens</i>
149	2211-31	hypothetical protein	<i>Arabidopsis thaliana</i>
150	2223-54	ORF YNL207w	<i>S. cerevisiae</i>
151	2224-94	14.3 kDa perchloric acid soluble protein	<i>Capra hircus</i>
152	2225-36	EST clone	<i>C. elegans</i>
1719	2228-2	BIGH3	<i>H. sapiens</i>
1720	2228-5	H protein	<i>H. sapiens</i>
1721	2228-8	ubiquinol-cytochrome c reductase	<i>Schizosaccharomyces pombe</i>
1722	2228-11	similar to mitochondrial ATPase inhibitors	<i>C. elegans</i>
1723	2228-16	Putative enzyme	<i>E. coli</i>
1724	2228-18	Ribosomal protein L7A	<i>Drosophila</i>
1725	2228-22	Troponin-I wings up A	<i>Drosophila</i>
1726	2228-25	tis gene product	<i>E. coli</i>
1727	2228-27	YCR521 gene product	<i>Saccharomyces cerevisiae</i>
1728	2228-28	putative transport system permease protein	<i>E. coli</i>
1729	2228-32	SapA protein	<i>E. coli</i>
1730	2228-34	Putative protein	<i>Arabidopsis thaliana</i>
1731	2228-37	Ada	<i>E. coli</i>
1732	2228-39	Titin	<i>H. sapiens</i>
1733	2228-42	adenylosuccinate synthetase	<i>Mus musculus</i>
1734	2228-43	transfer RNA-Ala synthetase	<i>B. mori</i>
1735	2228-44	C4 zinc finger DNA-binding protein	<i>Drosophila</i>
1736	2228-48	heme A: farnesyltransferase	<i>H. sapiens</i>
1737	2228-51	URF 4L (aa 1-96)	<i>Drosophila</i>
1738	2228-53	DOLICHOL-PHOSPHATE MANNOSYLTRANSFERASE	<i>E. coli</i>
1739	2228-58	troponin-T	<i>Drosophila</i>
1740	2228-59	protein disulfide isomerase	<i>Drosophila</i>
1741	2228-63	orf, hypothetical protein	<i>E. coli</i>
1742	2228-66	ilvl polypeptide	<i>E. coli</i>
1743	2228-68	orf, hypothetical protein	<i>E. coli</i>
1744	2228-72	Respiratory nitrate reductase 1 alpha chain	<i>E. coli</i>
1745	2228-77	homolog of virulence factor	<i>E. coli</i>
1746	2228-84	ORF o164	<i>E. coli</i>
1747	2228-91	nuclear protein E3-3 orf1	<i>Rattus norvegicus</i>
1748	2245-66	Troponin C	<i>Drosophila</i>
1749	2245-70	Predicted secreted protein	<i>Plasmodium falciparum</i>
1750	2245-72	Cytochrome C-1	<i>H. sapiens</i>
1751	2245-75	rpoB	<i>Plasmodium falciparum</i>
1752	2245-78	sarco(endo)plasmic reticulum-type calcium ATPase	<i>Heliothis virescens</i>
1753	2246-31	Ras-related GTP-binding protein	<i>H. sapiens</i>
1754	2246-57	Similar to inositol 1,4,5-triphosphate receptor	<i>C. elegans</i>
1755	2246-61	reverse transcriptase-like protein	<i>Aedes aegypti</i>
1756	2247-13	polyprotein	<i>Drosophila</i>

Table I (cont'd)

SEQ ID NO	Name	Genbank Homology	Organism
1757	2247-14	ORF2 for putative reverse transcriptase	<i>Drosophila</i>
1758	2247-42	Asparaginyl tRNA Synthetase	<i>H. sapiens</i>
1759	2247-44	calcium binding protein	<i>Drosophila</i>
1760	2247-58	similar to Fibronectin type III domain	<i>C. elegans</i>
1761	2247-62	reverse transcriptase	<i>Drosophila</i>
1762	2247-65	gag-like protein	<i>Culex pipiens</i>
1763	2247-79	L-3-phosphoserine phosphatase	<i>H. sapiens</i>
1764	2247-80	esterase E4	<i>Myzus persicae</i>
1765	2247-89	Similar to aldehyde dehydrogenase	<i>C. elegans</i>
1766	2248-76	O-44 protein	<i>Rattus sp.</i>
1767	2248-85	cDNA isolated for this protein using a monoclonal antibody directed against the p27k prosomal protein	<i>H. sapiens</i>
1768	2249-3	Projectin	<i>Drosophila</i>
1769	2249-5	ORF_ID:o312#14	<i>E. coli</i>
1770	2249-9	Heat shock protein 60	<i>Culicoides variipennis</i>
1771	2249-11	enigma protein	<i>H. sapiens</i>
1772	2249-12	alpha,alpha-trehalose glucohydrolase	<i>Oryctolagus cuniculus</i>
1773	2249-13	small GTP binding protein	<i>Drosophila</i>
1774	2249-14	Spermidine/putrescine transport system permease	<i>E. coli</i>
1775	2249-19	nueroendocrine-specific protein C	<i>H. sapiens</i>
1776	2249-21	a-agglutinin core subunit	<i>Saccharomyces cerevisiae</i>
1777	2249-24	KIAA0337	<i>H. sapiens</i>
1778	2249-34	su(wa) protein	<i>Drosophila</i>
1779	2249-42	regulator of kdp operon	<i>E. coli</i>
1780	2249-59	No definition line found	<i>C. elegans</i>
1781	2249-60	proline oxidase	<i>Drosophila</i>
1782	2249-62	Formate acetyltransferase	<i>E. coli</i>
1783	2249-70	similar to HECT-domain	<i>C. elegans</i>
1784	2249-75	PHOSPHORIBOSYLFORMYLGLYCINAMIDINE CYCLO-LIGASE	<i>E. coli</i>
1785	2249-77	Hypothetical 38.5 kd protein in agal-mtr intergenic region precursor	<i>E. coli</i>
1786	2249-85	D4L	<i>Variola virus</i>
1787	2249-87	similar to isocitrate dehydrogenase	<i>C. elegans</i>
1788	2250-6	Fii (head-tail joining;117)	<i>Bacteriophage Lambda</i>
1789	2250-7	possible NAGC-like transcriptional regulator	<i>E. coli</i>
1790	2250-10	cysteine string protein	<i>Bos taurus</i>
1791	2250-13	Tol B protein	<i>E. coli</i>
1792	2250-14	6-phosphogluconate dehydratase	<i>E. coli</i>
1793	2250-15	6-phosphogluconate dehydratase	<i>E. coli</i>
1794	2250-22	PSST subunit of the NADH: ubiquinone oxidoreductase	<i>Bos taurus</i>
1795	2250-30	sol i 3 antigen	<i>Solenopsis invicta</i>
1796	2250-36	predicted using Genefinder; similar to tRNA synthetases class I (E and Q	<i>C. elegans</i>
1797	2250-37	PNP	<i>H. sapiens</i>
1798	2250-42	ORF_ID:o331#2	<i>E. coli</i>
1799	2250-44	Extensin	<i>E. coli</i>

Table I (cont'd)

SEQ ID NO.	Name	Genbank Homology	Organism
1800	2250-47	ORF o654	<i>E. coli</i>
1801	2250-48	Gcap1 gene product	<i>Mus musculus</i>
1802	2250-52	similar to human MLH1 on chromosome 3p21	<i>Mus musculus</i>
1803	2250-53	Hypothetical 27.6 kd protein in hpt-panD intergenic region.	<i>E. coli</i>
1804	2250-58	UmuC protein	<i>E. coli</i>
1805	2250-61	dJ134E15.1 (Blimp-1	<i>H. sapiens</i>
1806	2250-63	ribosomal protein L23-related product homolog	<i>Rattus rattus</i>
1807	2250-65	hypothetical protein MJ1143	<i>E. coli</i>
1808	2250-68	HI0025 homolog	<i>E. coli</i>
1809	2250-77	R34094_1	<i>H. sapiens</i>
1810	2250-78	erythrocyte binding protein	<i>Plasmodium yoelii</i>
1811	2250-79	fosmidomycin resistance protein	<i>E. coli</i>
1812	2250-81	cyclophilin 1	<i>Drosophila</i>
1813	2250-83	putative glutamine synthetase	<i>E. coli</i>
1814	2251-3	J (tail:host specificity;1132)	<i>Bacteriophage Lambda</i>
1815	2251-5	Molybdopterin biosynthesis MoeB protein	<i>E. coli</i>
1816	2251-6	Fo-ATP synthase subunit b	<i>Drosophila</i>
1817	2251-9	citrate lyase alpha chain	<i>E. coli</i>
1818	2251-10	cuticle protein ACP65A	<i>Drosophila</i>
1819	2251-13	H repeat-associated protein in rhsC 3'region (orf-h3	<i>E. coli</i>
1820	2251-20	glycine-rich protein	<i>Arabidopsis thaliana</i>
1821	2251-23	2-oxoglutarate dehydrogenase precursor	<i>H. sapiens</i>
1822	2251-29	NFX1	<i>H. sapiens</i>
1823	2251-32	ebgR product, repressor	<i>E. coli</i>
1824	2251-41	neural protein	<i>Drosophila</i>
1825	2251-45	similar to unidentified ORF	<i>E. coli</i>
1826	2251-46	NADH:ubiquinone oxidoreductase b17.2 subunit	<i>Bos taurus</i>
1827	2251-49	tyrosine kinase	<i>Drosophila</i>
1828	2251-50	coded for by <i>C. elegans</i> cDNA yk89e9.5	<i>C. elegans</i>
1829	2251-57	H (tail component;853)	<i>Bacteriophage Lambda</i>
1830	2251-60	Lysyl tRNA Synthetase	<i>Drosophila</i>
1831	2251-62	7,8-diamino-pelargonic acid aminotransferase	<i>E. coli</i>
1832	2251-64	actin related protein	<i>Drosophila</i>
1833	2252-6	discs-large tumor suppressor	<i>Drosophila</i>
1834	2252-16	S-adenosylmethionine decarboxylase	<i>E. coli</i>
1835	2252-17	F52H3.5	<i>E. coli</i>
1836	2252-21	translationally controlled tumor protein	<i>Oryctolagus cuniculus</i>
1837	2252-31	GTP binding protein	<i>Rattus rattus</i>
1838	2252-34	mitochondrial porin transcript 1	<i>Drosophila</i>
1839	2252-38	cuticle protein	<i>Manduca sexta</i>
1840	2252-39	Similarity to Rat CD63 antigen	<i>C. elegans</i>
1841	2252-41	similar to <i>S. cerevisiae</i> Lpg20p	<i>E. coli</i>
1842	2252-48	cut E	<i>E. coli</i>
1843	2252-61	Histone H3	<i>Spisula solidissima</i>
1844	2252-66	ea10 (ssb;122)	<i>Bacteriophage Lambda</i>
1845	2252-71	Mao C protein	<i>E. coli</i>



Table I (cont'd)

SEQ ID NO	Name	Genbank Homology	Organism
1846	2252-72	miniparomyosin	<i>Drosophila</i>
1847	2252-73	pherophorin-S	<i>Volvox carteri</i>
1848	2252-80	cyclophilin	<i>Mus musculus</i>
1849	2252-84	alternate gene name yhhG	<i>E. coli</i>
1850	2222-20	nucleoporin Nup98	<i>rat</i>
1851	2222-21	hypothetical protein	<i>Escherichia coli</i>
1852	2222-36	ribosomal protein S11	<i>human</i>
1853	2222-39	hypothetical protein PFB0315w	<i>Plasmodium falciparans</i>
1854	2222-50	serine/threonine-specific protein k.	<i>Plasmodium falciparans</i>
1855	2222-58	hypothetical protein C25E10.9	<i>C. elegans</i>
1856	2222-64	transporting ATP synthase	<i>bovine</i>
1857	2222-94	tricarboxylate carrier	<i>rat</i>
1858	2218-95	anoxia upregulated protein	<i>Drosophila melanogaster</i>

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Table II represents a variety of flea HMT nucleic acid molecules of the present invention. Also cited in Table II are nucleic acid molecules from other organisms which share the closest sequence identity with the cited HMT sequences of the present invention, as determined by a search through the BLAST network as described above.

TABLE II

SEQ ID NO	Name	GenBank Homology	Organism
171	2094-23	mitochondrial ATP synthase, alpha subunit	<i>Drosophila melanogaster</i>
172	2104-20	mitochondrial ATP synthase	<i>Drosophila melanogaster</i>
173	2105-14	ATP synthase gamma-subunit	<i>Homo sapiens</i>
174	2167-72	oligomycin sensitivity conferring protein	<i>Drosophila melanogaster</i>
175	2179-20	ATPase 6	<i>Drosophila melanogaster</i>
176	2193-60	ATP synthase subunit B	<i>Schizaphis graminum</i>
177	2229-41	ATP synthase alpha subunit	<i>D. melanogaster</i>
178	2231-35	9 kD basic protein	<i>D. melanogaster</i>
179	2231-47	ATP synthase alpha-subunit	<i>Bos taurus</i>
180	2232-95	mitochondrial ATP synthase subunit 9	<i>Homo sapiens</i>
181	2084-56	Late embryogenesis abundant protein	<i>Picea glauca</i>
182	2084-36	TGF-beta masking protein/stranded at second	<i>Drosophila melanogaster</i>
183	2086-2	Argonaute protein	<i>Arabidopsis thaliana</i>
184	2196-92	like Drosophila HMPB homeotic proboscipedia protein	<i>C. elegans</i>
185	2092-27	DMDHEM2	<i>Drosophila melanogaster</i>
186	2094-21	SelD protein	<i>Drosophila melanogaster</i>
187	2106-11	Unr	<i>Rattus norvegicus</i>
188	2231-15	cno (canoe)	<i>D. melanogaster</i>
189	2230-79	ALR homologue	<i>D. melanogaster</i>
190	2232-42	saxophone serine-threonine kinase receptor	<i>D. melanogaster</i>
191	2232-68	selenophosphate synthetase	<i>D. melanogaster</i>
192	2088-11	MMTAX107, TAX responsive element binding protein	<i>Mus musculus</i>
193	2089-2	cs Dna J-1	<i>Cucumis sativus</i>
194	2090-7	Lethal (2) TID	<i>Drosophila melanogaster</i>
195	2102-33	monocytic leukaemia zinc finger protein	<i>homo sapiens</i>
196	2105-26	orf1 5' of EpoR	<i>Mus musculus</i>
197	2106-6	contains similarity to EGF-1	<i>C. elegans</i>
198	2106-9	HSP70 protein	<i>Ceratitidis capitata</i>
199	2084-60	82 kD heat shock protein	<i>Drosophila pseudobscura</i>
200	2108-59	PAR domain protein	<i>Drosophila melanogaster</i>
201	2156-34	yk29g12.3	<i>C. elegans</i>
202	2161-17	segmentation protein	<i>Drosophila melanogaster</i>
203	2162-28	heat shock protein 70, hsp70A2	<i>Anopheles albimanus</i>
204	2187-18	Heat shock protein 70	<i>Anopheles albimanus</i>
205	2173-77	Heat shock protein hsp70	<i>D. melanogaster</i>

Table II (cont'd)

SEQ ID NO	Name	GenBank Homology	Organism
206	2165-30	nucleolar protein	<i>Drosophila melanogaster</i>
207	2165-59	contains similarity to C4-type zinc fingers	<i>C. elegans</i>
208	2177-80	zinc finger protein	<i>Mus musculus</i>
209	2181-45	PAR domain protein 1	<i>Drosophila melanogaster</i>
210	2185-9	Heat shock protein-70	<i>Anopheles albimanus</i>
211	2185-82	segmentation protein	<i>Drosophila melanogaster</i>
212	2188-33	transcriptional repressor protein	<i>Drosophila melanogaster</i>
213	2203-18	Mastermind	<i>Drosophila virilis</i>
214	2205-82	high mobility group protein 1a	<i>Chironomus tentans</i>
215	2230-26	DNA repair protein	<i>D. melanogaster</i>
216	2230-71	homologue of seven in absentia	<i>Homo sapiens</i>
217	2230-89	nuclear speckle-type protein, SPOP	<i>Homo sapiens</i>
218	2230-96	heat shock protein	<i>D. melanogaster</i>
219	2231-7	hypothetical protein	<i>S.pombe</i>
220	2231-38	Rad51 homolog	<i>Bombyx mori</i>
221	2231-81	DNA repair protein	<i>D. melanogaster</i>
222	2232-2	cellular nucleic acid binding protein	<i>Xenopus laevis</i>
223	2234-63	heat shock protein 70	<i>Trichoplusia ni</i>
224	2232-77	actin-binding double-zinc-finger protein (abLIM)	<i>Homo sapiens</i>
225	2234-78	DNA-binding protein isoform I	<i>D. melanogaster</i>
226	2084-48	Allantoinase	<i>Rana catesbeiana</i>
227	2085-22	beta-glucuronidase	<i>E. coli</i>
228	2094-24	prolidase = peptidaseD/imidopeptidase	<i>Mus musculus</i>
229	2088-43	branched chain alpha-keto acid dehydrogenase E1-beta subunit	<i>Bos taurus</i>
230	2086-29	3-hydroxyisobutyrate dehydrogenase	<i>Dictyostelium discoideum</i>
231	2088-5	Rab 5c protein	<i>Canis familiaris</i>
232	2095-17	cytochrome P-450	<i>Heliothis virescens</i>
233	2102-16	carbamoyl phosphate synthetase II	<i>Plasmodium falciparans</i>
234	2102-48	NADPH cytochrome P450 reductase	<i>Musca domestica</i>
235	2104-15	branched chain alpha-keto acid dehydrogenase	<i>Rattus norvegicus</i>
236	2106-5	Metallothionein	<i>Strongylocentrotus purpuratus</i>
237	2106-47	peroxidoxin-1	<i>Dirofilaria immitis</i>
238	2107-17	tetracycline transporter-like protein	<i>Mus musculus</i>
239	2107-58	allergen Bla g 5 (glutathione-S-transferase)	<i>Blattella germanica</i>
240	2156-58	HAL-3 homologue	<i>Arabidopsis thaliana</i>
241	2195-90	aminoacylase-1	<i>Homo sapiens</i>
242	2171-55	NADPH—ferrihemoprotein reductase	<i>Drosophila melanogaster</i>
243	2169-30	hypothetical protein	<i>Synechocystis sp</i>
244	2169-52	insulin degrading enzyme	<i>Drosophila melanogaster</i>
245	2177-64	3-hydroxyisobutyrate dehydrogenase	<i>Rattus norvegicus</i>
246	2181-69	Endonexin	<i>Bos taurus</i>
247	2138-25	glutamate dehydrogenase	<i>Drosophila melanogaster</i>
248	2230-28	glutathione -S-transferase	<i>Anopheles gambiae</i>
249	2191-8	lactase-phlorizin hydrolase	<i>Rattus rattus</i>
250	2193-52	cytochrome P450	<i>Heliothis virescens</i>

Table II (cont'd)

SEQ ID NO	Name	GenBank Homology	Organism
251	2202-35	glutathione-S-transferase	<i>Anopheles gambiae</i>
252	2229-77	glutathione-S-transferase	<i>Anopheles gambiae</i>
253	2229-81	urate oxidase	<i>D. melanogaster</i>
254	2231-42	superoxide dismutase	<i>Cervus elaphus</i>
255	2232-74	allergen Bla g 5	<i>Blattella germanica</i>
256	2234-42	glutathione reductase family	<i>Musca domestica</i>
257	2087-8	cystic fibrosis transmembrane conductance regulator	<i>Homo sapiens</i>
258	2087-23	Nervous system antigen 2	<i>Drosophila melanogaster</i>
259	2091-56	adenosine triphosphatase	<i>Homo sapiens</i>
260	2094-20	sodium pump, alpha subunit	<i>Ctenocephalides felis</i>
261	2095-51	similar to Hrs	<i>C. elegans</i>
262	2103-24	N-methyl-D-aspartate receptor-associated protein	<i>Drosophila melanogaster</i>
263	2105-55	inward rectifying K channel	<i>Sus scrofa</i>
264	2105-63	EF-hand Ca <sup>2+</sup> binding protein p22	<i>Rattus norvegicus</i>
265	2106-62	Dents disease candidate gene product	<i>Homo sapiens</i>
266	2167-50	PKD1 (polycystic kidney disease 1)	<i>Fugu rubripes</i>
267	2185-37	copper-transporting ATPase	<i>Archaeoglobus fulgidus</i>
268	2193-29	TrkG Potassium transport protein	<i>E. coli</i>
269	2195-33	silicon transporter	<i>Cylindrotheca fusiformis</i>
270	2202-16	similarity to human sulfate anion transporter	<i>C. elegans</i>
271	2230-2	sulfate transporter	<i>Arabidopsis thaliana</i>
272	2230-69	mitochondrial porin	<i>D. melanogaster</i>
273	2231-22	muscarinic acetylcholine receptor	<i>D. melanogaster</i>
274	2231-24	p97 subunit of 15S Mg(2+)-ATPase	<i>Xenopus laevis</i>
275	2231-32	anion transporting ATPase	<i>Aquifex aeolicus</i>
276	2231-70	sulfate permease	<i>Schizosaccharomyces pombe</i>
277	2231-94	putative Na/H exchanger	<i>S.pombe</i>
278	2233-6	plasma membrane Ca <sup>2+</sup> -ATPase 2	<i>Mus musculus</i>
279	2233-24	chloride channel gene, CLIC2	<i>Homo sapiens</i>
280	2085-61	beta-type protein kinase C	<i>Bos taurus</i>
281	2089-20	cGMP-dependent protein kinase	<i>Drosophila melanogaster</i>
282	2092-12	Btk	<i>Homo sapiens</i>
283	2093-64	Receptor-like protein tyrosine phosphatase	<i>Drosophila melanogaster</i>
284	2095-31	frt (fms-related tyrosine kinase gene)	<i>Homo sapiens</i>
285	2094-58	casein kinase II beta	<i>Oryctolagus cuniculus</i>
286	2103-54	ORF YGL084c	<i>Saccharomyces cerevisiae</i>
287	2106-42	protein phosphatase epsilon subunit	<i>Homo sapiens</i>
288	2156-5	serine/threonine kinase	<i>Rattus norvegicus</i>
289	2157-95	cGMP-dependent protein kinase	<i>Drosophila melanogaster</i>
290	2165-80	ABL gene product	<i>Gallus gallus</i>
291	2165-63	diadenosine tetraphosphatase	<i>Homo sapiens</i>
292	2167-17	adenylate cyclase	<i>S. cerevisiae</i>
293	2177-44	serine/threonine kinase	<i>C. elegans</i>
294	2188-16	weakly similar to serine/threonine kinase	<i>C. elegans</i>
295	2191-60	carbohydrate kinase, pfkB family	<i>Archaeoglobus fulgidus</i>

Table II (cont'd)

SEQ ID NO	Name	GenBank Homology	Organism
296	2195-22	protein kinase	<i>Drosophila melanogaster</i>
297	2196-30	calcium-dependent protein kinase	<i>A. thaliana</i>
298	2205-83	protein kinase/endoribonuclease (IRE1)	<i>Homo sapiens</i>
299	2205-87	receptor tyrosine phosphatase	<i>Hirudo medicinalis</i>
300	2229-11	magnesium-dependent calcium inhibitable phosphatase	<i>Bos taurus</i>
301	2229-29	phosphoglycerate kinase	<i>Schistosoma mansoni</i>
302	2229-74	pyruvate kinase	<i>D. melanogaster</i>
303	2230-55	serine/threonine specific protein phosphatase 4	<i>D. melanogaster</i>
304	2230-57	stress activated MAP kinase kinase 3	<i>D. melanogaster</i>
305	2231-64	alkaline phosphatase	<i>D. melanogaster</i>
306	2231-91	polynucleotide phosphorylase	<i>Yersinia enterocolitica</i>
307	2232-43	protein kinase PkwA	<i>Thermomonospora curvata</i>
308	2234-94	serine/threonine kinase ULK1	<i>Homo sapiens</i>
309	2085-18	Pyridoxamine phosphate oxidase	<i>C. elegans</i>
310	2094-13	sphingomyelin phosphodiesterase	<i>Mus musculus</i>
311	2105-47	apolipoprotein E receptor 2	<i>Homo sapiens</i>
312	2092-38	squalene synthetase	<i>Homo sapiens</i>
313	2094-25	fatty acid synthetase	<i>Rattus norvegicus</i>
314	2089-32	coproporphyrinogen oxidase	<i>Homo sapiens</i>
315	2085-46	HADHB mitochondrial trifunctional protein beta subunit	<i>Homo sapiens</i>
316	2104-56	pyridoxal kinase	<i>Homo sapiens</i>
317	2107-30	Phosphomevalonate kinase	<i>Homo sapiens</i>
318	2154-70	very-long chain acyl-CoA dehydrogenase	<i>Mus musculus</i>
319	2191-85	stearyl-CoA desaturase	<i>Cyprinus carpio</i>
320	2192-44	very-long-chain Acyl-CoA dehydrogenase	<i>Rattus norvegicus</i>
321	2195-55	Similar to LDL receptor-related protein	<i>C. elegans</i>
322	2229-82	lipase-3	<i>D. melanogaster</i>
323	2231-59	Phosphatidylethanolamine-binding protein	<i>Macaca fascicularis</i>
324	2233-25	similarity to yeast ethanolaminephosphotransferase	<i>C. elegans</i>
325	2233-41	cellular retinoic acid binding protein (mCRABP)	<i>Manduca sexta</i>
326	2087-61	allergen	<i>Lepidoglyphus destructor</i>
327	2087-41	chloroquine resistance candidate protein	<i>Plasmodium falciparum</i>
328	2089-51	Xenopus Bf B	<i>Xenopus laevis</i>
329	2086-58	repeat organellar protein	<i>Plasmodium falciparum</i>
330	2090-45	heat shock cognate protein	<i>Drosophila melanogaster</i>
331	2104-23	40 kDa heat shock chaperone protein	<i>Deinococcus</i>
332	2107-26	Luciferase	<i>Photuris pennsylvanica</i>
333	2162-46	F20D1.9	<i>C. elegans</i>
334	2162-49	PKR inhibitor P58	<i>Bos taurus</i>
335	2162-93	GroES homologue	<i>Rickettsia</i>
336	2171-46	NH2 terminus uncertain	<i>Leishmania tarentolae</i>
337	2089-10	beta adaptin	<i>Drosophila melanogaster</i>
338	2229-24	non-functional folate binding protein	<i>Homo sapiens</i>
339	2229-25	calmodulin B	<i>Halocynthia roretzi</i>

Table II (cont'd)

SEQ. ID. NO.	Name	GenBank Homology	Organism
340	2229-31	putative T1/ST2receptor binding protein	<i>C. elegans</i>
341	2229-36	alpha-crystallin cognate protein 25	<i>Plodia interpunctella</i>
342	2229-40	Defensin	<i>Apis mellifera</i>
343	2229-86	glutamate—ammonia ligase	<i>D. melanogaster</i>
344	2231-49	melanoma-associated antigen ME491	<i>Homo sapiens</i>
345	2231-76	histone C	<i>Drosophila virilis</i>
346	2232-65	translationally controlled tumor protein	<i>Oryctolagus cuniculus</i>
347	2232-84	Apyrase	<i>Aedes aegypti</i>
348	2232-85	KIAA0124	<i>Homo sapiens</i>
349	2233-59	Glutamine-dependent carbamoyl-phosphate synthase	<i>C. elegans</i>
350	2233-86	ANG12 precursor	<i>Anopheles gambiae</i>
351	2234-11	tissue specific secretory protein	<i>Pan troglodytes</i>
352	2234-76	methionine adenosyltransferase	<i>D. melanogaster</i>
353	2089-13	Synaptic vessicle protein 2 form B	<i>Rattus norvegicus</i>
354	2159-52	glycoprotein 56	<i>Rattus norvegicus</i>
355	2084-6	CLN3; homologue of the gene underlying Batten disease	<i>Mus musculus</i>
356	2085-10	Amphiphysin	<i>Gallus gallus</i>
357	2156-39	glycoprotein 55	<i>Rattus norvegicus</i>
358	2104-59	Transmembrane transporter	<i>Discopyge ommata</i>
359	2105-9	insect intestinal mucin II	<i>Trichoplusia ni</i>
360	2106-14	kinesin-like protein	<i>D. melanogaster</i>
361	2107-45	Lazarillo precursor	<i>Schistocerca americana</i>
362	2156-3	clathrin-associated protein	<i>Mus musculus</i>
363	2161-46	neural variant mena+ protein	<i>Mus musculus</i>
364	2171-92	Malvolio	<i>Drosophila melanogaster</i>
365	2175-18	homolog of SYT – synaptotagmin	<i>Mus musculus</i>
366	2177-10	GABA receptor subunit (Rdl)	<i>Aedes aegypti</i>
367	2181-10	neurexin IV	<i>Drosophila melanogaster</i>
368	2191-92	synaptic vessicle protein 2B	<i>Rattus norvegicus</i>
369	2229-18	Synaptic vessicle protein 2A	<i>Rattus norvegicus</i>
370	2194-38	gamma-subunit of mouse nerve growth factor	<i>Mus musculus</i>
371	2230-60	lin-7-C	<i>Rattus norvegicus</i>
372	2230-81	PDZ domain protein	<i>Homo sapiens</i>
373	2234-5	Gcap1 gene product	<i>Mus musculus</i>
374	2234-55	Gcap1 gene product	<i>Mus musculus</i>
375	2234-71	Gcap1 gene product	<i>Mus musculus</i>
376	2085-34	Liver-specific transport protein	<i>Rattus norvegicus</i>
377	2087-15	polyspecific organic cation transporter	<i>Homo sapiens</i>
378	2204-80	transmembrane transporter	<i>Discopyge ommatta</i>
379	2093-39	liver-specific transport protein	<i>Rattus norvegicus</i>
380	2093-46	similar to monocarboxylate transporter family	<i>C. elegans</i>
381	2092-22	similar to matrin F/G	<i>C. elegans</i>
382	2103-50	Unknown	<i>Drosophila melanogaster</i>
383	2103-51	organic cation transporter	<i>Rattus norvegicus</i>
384	2197-35	renal organic cation transporter	<i>Oryctolagus cuniculus</i>
385	2156-17	sulfate anion transporter	<i>Manduca sexta</i>

Table II (cont'd)

SEQ ID NO	Name	GenBank Homology	Organism
386	2166-84	LX1	<i>Mus musculus</i>
387	2167-94	MCT (monocarboxylate transporter)	<i>Homo sapiens</i>
388	2196-83	renal organic cation transporter	<i>Oryctolagus cuniculus</i>
389	2229-83	similarity to monocarboxylate transporter 1	<i>C. elegans</i>
390	2231-89	Golgi 4-transmembrane spanning transporter MTP	<i>Mus musculus</i>
391	2158-8	phosphate carrier protein	<i>C. elegans</i>
392	2085-14	ADP/ATP translocase	<i>Drosophila melanogaster</i>
393	2085-17	Na <sup>+</sup> -dependent inorganic phosphatase cotransporter	<i>Drosophila melanogaster</i>
394	2088-38	ADP/ATP translocase	<i>Bos taurus</i>
395	2092-50	ADP/ATP translocase	<i>Drosophila melanogaster</i>
396	2104-21	Na(+)-dependent inorganic phosphate cotransporter	<i>Drosophila melanogaster</i>
397	2121-55	phosphate carrier protein	<i>C. elegans</i>
398	2105-64	phosphate carrier protein	<i>Homo sapiens</i>
399	2102-6	ZK512.6	<i>C. elegans</i>
400	2108-27	mitochondrial phosphate carrier protein	<i>Homo sapiens</i>
401	2194-63	mitochondrial phosphate transporter	<i>Rattus norvegicus</i>
402	2196-14	phosphate/triose-phosphate translocator precursor	<i>C. elegans</i>
403	2204-11	EST clone	<i>D. melanogaster</i>
404	2085-16	Chymotrypsin I	<i>Anopheles gambiae</i>
405	2085-54	Chymotrypsin II	<i>Anopheles gambiae</i>
406	2086-12	Plasminogen	<i>Homo sapiens</i>
407	2086-18	Trypsin eta	<i>Drosophila melanogaster</i>
408	2090-21	Trypsin	<i>Manduca sexta</i>
409	2092-15	Alp1	<i>Cochliobolus carbonum</i>
410	2102-11	vitellin-degrading protease	<i>Bombyx mori</i>
411	2102-17	Chymotrypsin II	<i>Anopheles gambiae</i>
412	2102-51	chymotrypsin -like protease	<i>Anopheles gambiae</i>
413	2103-31	Beta trypsin	<i>Drosophila erecta</i>
414	2107-22	Factor IX	<i>Rattus norvegicus</i>
415	2108-29	Trypsin	<i>Anopheles stephensi</i>
416	2157-15	Trypsin	<i>Choristoneura fumiferana</i>
417	2160-34	Aminopeptidase	<i>Synechocystis</i>
418	2160-36	E01G6.1	<i>C. elegans</i>
419	2103-62	plasminogen activator inhibitor 2	<i>Mus musculus</i>
420	2167-36	factor IX	<i>Oryctolagus cuniculus</i>
421	2167-67	Alp1	<i>Cochliobolus carbonum</i>
422	2169-51	Trypsin	<i>Aedes aegypti</i>
423	2181-27	Chymotrypsin BII	<i>Penaeus vannamei</i>
424	2185-69	plasma prekallikrein	<i>Homo sapiens</i>
425	2187-20	pre-procathepsin L	<i>Paragonimus westermani</i>
426	2188-45	vitellin-degrading protease	<i>Bombyx mori</i>
427	2192-91	late trypsin precursor	<i>Culex pipiens quinquefasciatus</i>
428	2196-10	SPC2	<i>Branchiostoma californiensis</i>
429	2196-88	Trypsin	<i>Anopheles stephensi</i>

Table II (cont'd)

SEQ. ID NO.	Name	GenBank Homology	Organism
430	2204-9	carnitine/choline acetyltransferase	<i>C. elegans</i>
431	2229-7	iota trypsin	<i>D. melanogaster</i>
432	2229-22	Trypsin	<i>Anopheles gambiae</i>
433	2229-89	Trypsin	<i>Anopheles gambiae</i>
434	2229-94	late trypsin precursor	<i>Culex pipiens quinquefasciatus</i>
435	2230-59	Chymotrypsin 1	<i>Anopheles gambiae</i>
436	2230-67	carboxypeptidase A	<i>Drosophila heteroneura</i>
437	2231-62	aminopeptidase N	<i>Sus scrofa</i>
438	2231-74	limulus factor C serine protease	<i>Tachypleus tridentatus</i>
439	2232-15	cysteine proteinase	<i>Sitophilus zeamais</i>
440	2232-25	Carboxypeptidase	<i>Simulium vitatum</i>
441	2232-33	putative aspartic protease	<i>Brassica oleracea</i>
442	2233-46	aminopeptidase N	<i>Pleuronectes americanus</i>
443	2233-85	chymotrypsin 1	<i>Anopheles gambiae</i>
444	2233-90	Trypsin	<i>Anopheles stephensi</i>
445	2233-94	preprechymotrypsin 1	<i>Penaeus vannamei</i>
446	2234-29	chymotrypsin-like protease precursor	<i>Aedes aegypti</i>
447	2234-58	Putative	<i>C. elegans</i>
448	2234-61	carboxylesterase precursor	<i>Aphis gossypii</i>
449	2234-68	serine protease inhibitor I	<i>Schistocerca gregaria</i>
450	2084-35	Integral membrane protein	<i>Mus musculus</i>
451	2086-45	similar to beta-ureidopropionase of Rat	<i>C. elegans</i>
452	2087-54	Cyclin	<i>Mus musculus</i>
453	2088-22	Esp 8	<i>Mus musculus</i>
454	2091-16	contains similarity to EGF-like domains	<i>C. elegans</i>
455	2091-29	multiple exostosis-like protein	<i>Homo sapiens</i>
456	2091-30	apoptosis 1 inhibitor	<i>Drosophila melanogaster</i>
457	2092-33	KIAA0023 (putitive oncogene)	<i>Homo sapiens</i>
458	2095-35	G coupled receptor	<i>C. elegans</i>
459	2095-3	Go (heterotrimeric guanyl nucleotide binding protein alpha subunit)	<i>Manduca sexta</i>
460	2085-4	gp 150 protein	<i>Drosophila melanogaster</i>
461	2103-28	leukotriene A4 hydrolase	<i>Rattus sp.</i>
462	2105-62	putitive orf	<i>Homo sapiens</i>
463	2107-6	activator protein	<i>Drosophila melanogaster</i>
464	2107-28	platelet-endothelial tetraspan antigen 3	<i>Homo sapiens</i>
465	2189-3	oligopeptidase A (prlC)	<i>Haemophilis influenzae</i>
466	2156-54	fibroblast growth factor receptor	<i>Xenopus laevis</i>
467	2160-92	contains similarity to EGF-like domains	<i>C. elegans</i>
468	2160-65	weak similarity to the drosophila hyperplastic disc protein	<i>C. elegans</i>
469	2165-53	inositol triphosphate receptor	<i>Rattus norvegicus</i>
470	2166-22	placental protein 11	<i>Homo sapiens</i>
471	2166-92	elongation factor 1 alpha-like	<i>Drosophila melanogaster</i>
472	2181-34	DSch	<i>Drosophila melanogaster</i>
473	2192-65	STAM, signal transducing adaptor molecule	<i>Homo sapiens</i>
474	2194-24	ATPases associated with various cellular activities (AAA family)	<i>Arabidopsis thaliana</i>



Table II (cont'd)

SEQ ID NO	Name	GenBank Homology	Organism
475	2196-75	similar to cell division control protein	<i>C. elegans</i>
476	2230-38	EST clone	<i>S. cerevisiae</i>
477	2230-39	NTPase	<i>D. melanogaster</i>
478	2230-66	adenylyl cyclase aggregation protein	<i>Dictyostelium discoideum</i>
479	2230-80	sphingomyelin phosphodiesterase	<i>C. elegans</i>
480	2231-29	nuclear antigen H731	<i>Homo sapiens</i>
481	2231-40	suppressor of actin mutation 2	<i>Homo sapiens</i>
482	2231-66	DET1	<i>Arabidopsis thaliana</i>
483	2232-7	Calreticulin	<i>D. melanogaster</i>
484	2232-38	activator protein	<i>D. melanogaster</i>
485	2232-69	ornithine decarboxylase	<i>Gallus gallus</i>
486	2233-32	similar bHLH-PAS	<i>D. melanogaster</i>
487	2233-45	rab1	<i>D. melanogaster</i>
488	2234-2	C10A gene product	<i>Mus musculus</i>
489	2234-72	QM homolog	<i>D. melanogaster</i>
490	2084-17	Integral membrane protein	<i>Herpesvirus-2</i>
491	2091-4	endomembrane protien EMP70 precursor isolog	<i>Arabidopsis thaliana</i>
492	2102-45	Ylr251wp	<i>Saccharomyces cerevisiae</i>
493	2162-68	220 kDa silk protein	<i>Chironomus thummi</i>
494	2160-47	precursor HT7 protein	<i>Gallus gallus</i>
495	2161-12	peritrophin 95 precursor	<i>Lucilia cuprina</i>
496	2161-15	yk86g11.5	<i>C. elegans</i>
497	2171-12	51A surface protein	<i>Paramecium tetraurelia</i>
498	2173-18	hypothetical – mitochondrial membrane transport protein	<i>Schizosaccharomyces pombe</i>
499	2087-32	est sequence	<i>C. elegans</i>
500	2091-19	Similar to P. aeruginosa hypothetical protein	<i>C. elegans</i>
501	2192-86	tyrosine kinase	<i>Drosophila melanogaster</i>
502	2086-42	M04B2.4	<i>C. elegans</i>
503	2088-16	glycoprotein 330	<i>C. elegans/Human</i>
504	2088-39	EST sequence	<i>Arabidopsis thaliana</i>
505	2088-57	Yer 126cp	<i>Saccharomyces cerevisiae</i>
506	2089-25	similar to S. cerevisiae hypothetical protein YKL166	<i>C. elegans</i>
507	2090-3	EST sequence	<i>Saccharomyces cerevisiae</i>
508	2090-53	EST sequence	<i>C. elegans</i>
509	2095-20	Chloroplast ORF	<i>Marchantia polymorpha</i>
510	2102-28	similar to S. cerevisiae hypothetical protein YKL166	<i>C. elegans</i>
511	2102-55	D1054.3	<i>C. elegans</i>
512	2102-58	ZC513.5 gene product	<i>C. elegans</i>
513	2105-44	E 1087 protein	<i>Saccharomyces cerevisiae</i>
514	2109-24	F11C1.5	<i>C. elegans</i>
515	2154-21	disulfide-like protein	<i>Acanthamoeba castellanii</i>
516	2156-6	ZK470.1	<i>C. elegans</i>
517	2156-18	BIIIA3	<i>Ovis aries</i>
518	2156-27	AFR1	<i>S. cerevisiae</i>
519	2165-94	COS41.8	<i>Ciona intestinalis</i>

Table II (cont'd)

SEQ ID NO	Name	GenBank Homology	Organism
520	2167-65	EST sequence, function unknown	<i>C. elegans</i>
521	2171-93	KIAA0160	<i>Homo sapiens</i>
522	2175-45	ORF YJR83.18	<i>S. cerevisiae</i>
523	2185-66	rps4	<i>Plasmodium falciparum</i>
524	2195-40	C27C12.4	<i>C. elegans</i>
525	2196-20	glycoprotein A	<i>Pneumocystis carinii</i>
526	2205-89	BKRF1 encodes EBNA-1 protein	<i>Epstein Barr virus</i>
527	2229-19	D4L	<i>Variola virus</i>
528	2230-35	KIAA0747	<i>Homo sapiens</i>
529	2231-8	I3	<i>Mus musculus</i>
530	2231-78	unknown protein	<i>Arabidopsis thaliana</i>
531	2232-49	Similarity to Yeast hypothetical 52.9 KD protein	<i>C. elegans</i>
532	2232-52	tetratricopeptide repeat protein (tpr2)	<i>Homo sapiens</i>
533	2233-5	similar to <i>Saccharomyces cerevisiae</i> SCD6 protein	<i>C. elegans</i>
534	2233-22	cDNA EST yk486b9.3	<i>C. elegans</i>
535	2233-93	CDC27Dm	<i>D. melanogaster</i>
536	2084-34	Immune suppressor/V-ATPase 115 kDa subunit	<i>Mus musculus</i>
537	2086-30	V-ATPase A-subunit	<i>Aedes aegypti</i>
538	2087-45	H <sup>+</sup> ATPase	<i>Drosophila melanogaster</i>
539	2088-55	40-kDa-V-ATPase subunit	<i>Manduca sexta</i>
540	2088-62	vacuolar ATPase subunit A	<i>Drosophila melanogaster</i>
541	2091-26	proton-ATPase-like protein	<i>Homo sapiens</i>
542	2091-31	vacuolar ATPase subunit A	<i>Drosophila melanogaster</i>
543	2092-20	vacuolar ATPase 115 kDa subunit	<i>Homo sapiens</i>
544	2095-18	similar to <i>S. cerevisiae</i> vacuolar H(+)-ATPase 54 kD subunit	<i>C. elegans</i>
545	2095-54	H (+)-transporting ATPase subunit B	<i>Manduca sexta</i>
546	2108-8	similar to <i>S. cerevisiae</i> 54 kDa V-ATPase subunit	<i>C. elegans</i>
547	2154-36	V-ATPase subunit E	<i>Drosophila melanogaster</i>
548	2154-76	V-ATPase subunit A (new fragment)	<i>Aedes aegypti</i>
549	2166-32	V-ATPase C subunit	<i>Drosophila melanogaster</i>
550	2166-33	vacuolar (V-type) H(+)-ATPase B subunit	<i>Helicoverpa virescens</i>
551	2166-90	beta subunit of ATPase	<i>Schizaphis graminum</i>
552	2161-5	ATPase I	<i>Plasmodium falciparum</i>
553	2171-24	similar to V-ATPase 116kd subunit	<i>C. elegans</i>
554	2169-82	V-ATPase subunit E	<i>Drosophila melanogaster</i>
555	2187-36	V-ATPase membrane sector associated protein M8-9	<i>Homo sapiens</i>
556	2188-91	V-ATPase subunit A	<i>Candida tropicalis</i>
557	2230-88	vacuolar ATPase G subunit	<i>Manduca sexta</i>
558	2232-61	V-ATPase subunit C	<i>D. melanogaster</i>
559	2086-52	Penelope transposable element ORF	<i>Drosophila virilis</i>
560	2103-2	genome polyprotein gene product	<i>Plum pox virus</i>
561	2106-8	pol protein	<i>Human T-cell lymphotropic virus type 2</i>
562	2108-41	reverse transcriptase, Doc retroposon	<i>Drosophila melanogaster</i>

Table II (cont'd)

SEQ ID NO	Name	GenBank Homology	Organism
563	2202-28	Polypeptide	<i>Hepatitis virus C</i>
564	2165-95	DNA polymerase	<i>Choristoneura biennis entomopoxvirus</i>
565	2169-81	reverse transcriptase	<i>Drosophila melanogaster</i>
566	2181-36	reverse transcriptase	<i>Anopheles gambiae</i>
1416	2240-4	alpha-L-fucosidase precursor	<i>Homo sapiens</i>
1417	2240-11	estrogen related receptor alpha	<i>Mus musculus</i>
1418	2240-14	NADH:ubiquinone oxidoreductase 51-kD subunit	<i>Homo sapiens</i>
1419	2240-17	peritrophin 1	<i>Anopheles gambiae</i>
1420	2240-19	small GTPase rac1b	<i>Homo sapiens</i>
1421	2240-23	Symplekin	<i>Homo sapiens</i>
1422	2240-26	ribosomal protein L30	<i>Bos taurus</i>
1423	2240-28	60S Ribosomal Protein RPL10A	<i>Homo sapiens</i>
1424	2240-29	KIN17 protein	<i>D. melanogaster</i>
1425	2240-31	eukaryotic initiation factor 4 gamma	<i>Homo sapiens</i>
1426	2240-38	ornithine decarboxylase antizyme	<i>D. melanogaster</i>
1427	2240-44	electron transfer flavoprotein	<i>Rattus norvegicus</i>
1428	2240-53	EST clone	<i>C. elegans</i>
1429	2240-55	glutathione reductase family	<i>Musca domestica</i>
1430	2240-58	chymotrypsin-like serine protease	<i>C. felis</i>
1431	2240-63	ferritin subunit 1	<i>D. melanogaster</i>
1432	2240-64	vacuolar ATPase subunit B	<i>D. melanogaster</i>
1433	2240-66	chaperonin containing TCP-1 delta	<i>Fugu rubripes</i>
1434	2240-70	1-acyl-glycerol-3-phosphate acyltransferase	<i>Zea mays</i>
1435	2240-71	EST clone AL021106	<i>D. melanogaster</i>
1436	2240-72	376aa long hypothetical dehydrogenase	<i>Pyrococcus horikoshii</i>
1437	2240-77	chymotrypsin-like serine protease	<i>C. felis</i>
1438	2240-80	EST clone	<i>C. elegans</i>
1439	2240-83	chymotrypsin-like serine protease	<i>C. felis</i>
1440	2240-90	cytochrome P450	<i>D. melanogaster</i>
1441	2240-93	enhancer-trap-locus-1	<i>Mus musculus</i>
1442	2240-94	glycerol-3-phosphate dehydrogenase	<i>Ceratitis capitata</i>
1443	2241-3	FS-H precursor	<i>Ctenocephalides felis</i>
1444	2241-5	trypsin-like serine protease	<i>Ctenocephalides felis</i>
1445	2241-7	myospheroid protein	<i>D. melanogaster</i>
1446	2241-10	Sam50	<i>D. melanogaster</i>
1447	2241-12	NADH dehydrogenase subunit 2	<i>Chorthippus parallelus</i>
1448	2241-15	putative protein	<i>Arabidopsis thaliana</i>
1449	2241-16	contains EGF-like repeats	<i>C. elegans</i>
1450	2241-20	Gcap1 gene product	<i>Mus musculus</i>
1451	2241-25	Na(+)-dependent inorganic phosphate cotransporter	<i>D. melanogaster</i>
1452	2241-31	D4L	<i>Variola virus</i>
1453	2241-36	plenty-of-prolines-101; POP101; SH3-philo-protein	<i>Mus musculus</i>
1454	2241-40	EF-1-alpha	<i>D. melanogaster</i>

Table II (cont'd)

SEQ ID NO	Name	GenBank Homology	Organism
1455	2241-44	F1-ATP synthase epsilon-subunit	<i>Ipomoea batatas</i>
1456	2241-54	ribosomal protein S28	<i>Homo sapiens</i>
1457	2241-55	Y-box protein	<i>D. melanogaster</i>
1458	2241-56	short-chain alcohol dehydrogenase	<i>Homo sapiens</i>
1459	2241-59	contains 3 cysteine rich repeats	<i>C. elegans</i>
1460	2241-60	muscle type phosphofructokinase	<i>Canis familiaris</i>
1461	2241-61	Heat shock protein 82	<i>Mus musculus</i>
1462	2241-65	chymotrypsin-like protease	<i>C. felis</i>
1463	2241-66	Oligosaccharyltransferase subunit	<i>D. melanogaster</i>
1464	2241-70	EST clone	<i>D. melanogaster</i>
1465	2241-72	failed axon connections protein	<i>D. melanogaster</i>
1466	2241-74	Enolase	<i>Hymenolepis diminuta</i>
1467	2241-78	multiple exostosis 2 protein	<i>Mus musculus</i>
1468	2241-80	Protein on Ecdysone Puffs	<i>D. melanogaster</i>
1469	2241-82	paramyosin	<i>D. melanogaster</i>
1470	2241-83	beta-tubulin	<i>Bombyx mori</i>
1471	2241-84	natural killer cell enhancing factor	<i>Cyprinus carpio</i>
1472	2241-86	similar to MYOTUBULARIN-RELATED PROTEIN	<i>Homo sapiens</i>
1473	2241-87	Renin	<i>Rattus norvegicus</i>
1474	2241-90	Myophilin	<i>Echinococcus multilocularis</i>
1475	2243-10	alpha-actinin	<i>D. melanogaster</i>
1476	2243-11	monocarboxylate transporter	<i>Homo sapiens</i>
1477	2243-13	yk278a10.3	<i>C. elegans</i>
1478	2243-15	selenium donor protein	<i>Homo sapiens</i>
1479	2243-18	acetyl-CoA synthetase	<i>D. melanogaster</i>
1480	2243-20	cytochrome P450 CYP12A3	<i>Musca domestica</i>
1481	2243-22	NADH dehydrogenase subunit 4	<i>Anopheles arabiensis</i>
1482	2243-27	Polyubiquitin	<i>Cricetulus griseus</i>
1483	2243-28	Moesin	<i>D. melanogaster</i>
1484	2243-31	QM protein	<i>Bombyx mandarina</i>
1485	2243-32	Sec23 protein	<i>Homo sapiens</i>
1486	2243-37	truncated protein	<i>S. cerevisiae</i>
1487	2243-38	Projectin	<i>D. melanogaster</i>
1488	2243-39	Unknown	<i>Homo sapiens</i>
1489	2243-41	similar to enoyl-CoA hydratase	<i>C. elegans</i>
1490	2243-45	similar to dehydrogenase	<i>C. elegans</i>
1491	2243-46	trypsin-like serine protease	<i>C. felis</i>
1492	2243-48	Merlin	<i>Rattus norvegicus</i>
1493	2243-52	GTP-specific succinyl-CoA synthetase beta subunit	<i>Homo sapiens</i>
1494	2243-53	sod protein (superoxide dismutase)	<i>Drosophila virilis</i>
1495	2243-54	trypsin-like serine protease	<i>C. felis</i>
1496	2243-61	chymotrypsin-like serine protease	<i>C. felis</i>
1497	2243-66	Tag B	<i>Dictyostelium discoideum</i>
1498	2243-67	hypothetical protien	<i>Arabidopsis thaliana</i>
1499	2243-68	heat shock cognate protein 70	<i>Trichoplusia ni</i>

Table II (cont'd)

FC-6-C1

SEQ ID NO	Name	GenBank Homology	Organism
1500	2243-72	TRIP-1 homologue	<i>D. melanogaster</i>
1501	2243-73	cytosolic NADP-dependent isocitrate dehydrogenase	<i>Microtis mexicanis</i>
1502	2243-86	progesterone-induced protein	<i>Oryctolagus cuniculus</i>
1503	2243-87	Bmsqd-2	<i>Bombyx mori</i>
1504	2243-91	sodium/iodide symporter	<i>Homo sapiens</i>
1505	2243-92	ORF2	<i>Acidianus ambivalens</i>
1506	2243-94	lysosomal beta-galactosidase	<i>Felis cattus</i>
1507	2244-12	tropomyosin isoform 127	<i>D. melanogaster</i>
1508	2244-19	KIAA0181	<i>Homo sapiens</i>
1509	2244-23	plasma membrane calcium ATPase isoform 1	<i>Homo sapiens</i>
1510	2244-29	NADH dehydrogenase	<i>Bos taurus</i>
1511	2244-44	glutamate dehydrogenase	<i>D. melanogaster</i>
1512	2244-54	spliceosomal protein	<i>D. melanogaster</i>
1513	2244-59	ciliary body glutathione peroxidase	<i>Bos taurus</i>
1514	2244-61	pyridoxal-phosphate-dependent aminotransferases	<i>C. elegans</i>
1515	2244-64	Unknown	<i>Rattus norvegicus</i>
1516	2244-69	trypsin-like serine protease	<i>C. felis</i>
1517	2244-71	peritrophin 1	<i>Anopheles gambiae</i>
1518	2244-75	NADH dehydrogenase subunit 5	<i>Anopheles gambiae</i>
1519	2244-84	microsomal epoxide hydrolase	<i>Rattus norvegicus</i>
1520	2244-86	C54G7.2 gene product	<i>C. elegans</i>
1521	2244-91	Aminopeptidase N	<i>Plutella xylostella</i>
1522	2253-2	cytochrome C oxidase	<i>H. sapiens</i>
1523	2253-13	Initiation factor 5A	<i>Gallus gallus</i>
1524	2253-14	protein phosphatase type 2A catalytic subunit	<i>Bos taurus</i>
1525	2253-16	myosin light chain 2	<i>D. melanogaster</i>
1526	2253-18	cDNA EST yk462d1.5	<i>C. elegans</i>
1527	2253-19	ribosomal protein S10	<i>H. sapiens</i>
1528	2253-24	aspartyl(asparaginy)l-beta-hydroxylase, HAAH	<i>H. sapiens</i>
1529	2253-27	larval and adult myosin heavy chain	<i>D. melanogaster</i>
1530	2253-33	nervous system antigen 2	<i>D. melanogaster</i>
1531	2253-36	dJ366N23.2	<i>H. sapiens</i>
1532	2253-40	hrp48.1	<i>D. melanogaster</i>
1533	2253-42	ZnT-1	<i>Mus musculus</i>
1534	2253-43	aminopeptidase N	<i>Manduca sexta</i>
1535	2253-56	Profilin	<i>D. melanogaster</i>
1536	2253-59	T26A5.	<i>H. sapiens</i>
1537	2253-68	NADH-ubiquinone oxidoreductase 42 kDa subunit	<i>D. melanogaster</i>
1538	2253-78	glycine-rich protein	
1539	2253-81	5'-nucleotidase	<i>H. sapiens</i>
1540	2253-86	glutathione S-transferase	<i>Anopheles gambiae</i>
1541	2253-87	ferritin subunit 1	<i>D. melanogaster</i>
1542	2253-92	myosin light chain 2	<i>D. melanogaster</i>
1543	2253-94	xylose-proton symport	<i>E. coli</i>
1544	2254-4	mature-parasite-infected erythrocyte surface antigen	<i>P. falciparum</i>

Table II (cont'd)

SEQ ID.NO:	Name	GenBank Homology	Organism
1545	2254-6	Fo-ATP synthase subunit b	<i>D. melanogaster</i>
1546	2254-13	similar to Arabidopsis thaliana male sterility protein 2	<i>C. elegans</i>
1547	2254-17	CLN3 protein	<i>H. sapiens</i>
1548	2254-21	YbgG	<i>B. subtilis</i>
1549	2254-25	peroxisomal protein	<i>Synechocystis sp</i>
1550	2254-27	Glutaminase	<i>Rattus norvegicus</i>
1551	2254-30	tartan protein	<i>D. melanogaster</i>
1552	2254-33	leucine zipper-EF-hand containing transmembrane protein 1	<i>H. sapiens</i>
1553	2254-39	similar to helicase	<i>C. elegans</i>
1554	2254-43	muscle myosin heavy chain	<i>D. melanogaster</i>
1555	2254-45	putative nicotinate phosphoribosyltransferase	<i>N. tabacum</i>
1556	2254-51	60S ribosomal protein	<i>Mus musculus</i>
1557	2254-54	small nuclear riboprotein Sm-D	<i>H. sapiens</i>
1558	2254-55	nucleoside diphosphate kinase	<i>Salmo salar</i>
1559	2254-60	serine protease	<i>C. felis</i>
1560	2254-63	myospheroid protein	<i>D. melanogaster</i>
1561	2254-65	Carboxylesterase	<i>Anisopteromalus calandrae</i>
1562	2254-66	siah binding protein 1	<i>H. sapiens</i>
1563	2254-70	vacuolar ATPase, subunit M9.7	<i>Manduca sexta</i>
1564	2254-83	Fumarylacetoacetate hydrolase	<i>Rattus norvegicus</i>
1565	2254-84	metalloproteinase 1	<i>Hydra vulgaris</i>
1566	2254-88	alpha-spectrin	<i>D. melanogaster</i>
1567	2254-93	NADH dehydrogenase subunit 6	<i>D. melanogaster</i>
1568	2254-96	cyclophilin isoform 5	<i>C. elegans</i>
1569	2255-5	similar to mitochondrial ATPase inhibitors	<i>C. elegans</i>
1570	2255-8	yk391f12.5	<i>C. elegans</i>
1571	2255-12	Unknown	<i>H. sapiens</i>
1572	2255-17	ribonucleotide reductase subunit M1	<i>M. musculus</i>
1573	2255-19	docking protein	<i>H. sapiens</i>
1574	2255-22	Similar to rat 5E5 antigen	<i>H. sapiens</i>
1575	2255-23	ribosomal protein S31	<i>D., melanogaster</i>
1576	2255-25	Similar to acyl-CoA dehydrogenase	<i>C. elegans</i>
1577	2255-28	Arginine tyrosine kinase	<i>H. sapiens</i>
1578	2255-32	ribosomal protein L7a	<i>D., melanogaster</i>
1579	2255-33	chS-Rex-s	<i>G. gallus</i>
1580	2255-39	Phosphoacetylglucosamine mutase	<i>C. elegans</i>
1581	2255-41	NADH dehydrogenase subunit 6	<i>D., melanogaster</i>
1582	2255-45	tRNA-glutamine synthetase	<i>C. elegans</i>
1583	2255-46	p68	<i>M. musculus</i>
1584	2255-49	ABC8	<i>M. musculus</i>
1585	2255-50	kynurenine aminotransferase	<i>R. rattus</i>
1586	2255-51	SmD homolog {Gly-Arg repeat}	<i>M. musculus</i>
1587	2255-56	epoxide hydrolase	<i>S. scrofa</i>
1588	2255-60	Sec23 protein	<i>H. sapiens</i>
1589	2255-62	HMG CoA synthase	<i>M. musculus</i>
1590	2255-63	dipeptidyl aminopeptidase-like protein 6	<i>M. musculus</i>

Table II (cont'd)

SEQ ID: NO.	Name	GenBank Homology	Organism
1591	2255-66	retinal rod Na <sup>+</sup> /Ca <sup>+</sup> , K <sup>+</sup> exchanger	<i>H. sapiens</i>
1592	2255-67	4-hydroxybutyrate coenzyme A transferase	<i>C. elegans</i>
1593	2255-70	hD54+ins2 isoform	<i>H. sapiens</i>
1594	2255-73	chromaffin granule ATPase II homolog	<i>M. musculus</i>
1595	2255-77	40S ribosomal protein S10	<i>H. sapiens</i>
1596	2255-79	34/67 kD laminin binding protein	<i>S. purpuratus</i>
1597	2255-82	RNA-binding protein lark	<i>D., melanogaster</i>
1598	2255-86	thiol-specific antioxidant protein	<i>R. norvegicus</i>
1599	2256-7	Similar to Human estrogen-responsive finger protein	<i>H. sapiens</i>
1600	2256-11	Trypsin	<i>C. felis</i>
1601	2256-12	CEV14	<i>H. sapiens</i>
1602	2256-16	AL021475	<i>C. elegans</i>
1603	2256-21	Heterogenous Nuclear Ribonucleoprotein C1	<i>H. sapiens</i>
1604	2256-22	b4 integrin interactor	<i>H. sapiens</i>
1605	2256-28	testis enhanced gene transcript protein	<i>H. sapiens</i>
1606	2256-31	synaptic vesicle protein 2B	<i>R. norvegicus</i>
1607	2256-40	TNF-alpha stimulated ABC protein	<i>H. sapiens</i>
1608	2256-42	carboxypeptidase A	<i>H. armigera</i>
1609	2256-46	pherophorin S	<i>V. carteri</i>
1610	2256-52	Fo-ATP synthase subunit b	<i>D. melanogaster</i>
1611	2256-54	PDGF associated protein	<i>H. sapiens</i>
1612	2256-58	S20 ribosomal protein	<i>D. melanogaster</i>
1613	2256-64	ribosomal protein S9	<i>H. sapiens</i>
1614	2256-69	elongation factor 1-gamma	<i>Artemia sp</i>
1615	2256-70	conserved hypothetical protein	<i>S. pombe</i>
1616	2256-72	fructose 1,6 bisphosphate-aldolase 4C	<i>D. melanogaster</i>
1617	2256-73	troponin-T	<i>D. melanogaster</i>
1618	2256-80	SRP14	<i>C. familiaris</i>
1619	2256-82	succinyl-CoA synthetase alpha subunit	<i>S. scrofa</i>
1620	2256-89	Csa-19	<i>H. sapiens</i>
1621	2256-92	Sacm21	<i>M. musculus</i>
1622	2256-94	apoptosis inhibitor	<i>Cydia pomonella granulosis virus</i>
1623	2256-96	ribosomal protein L22	<i>D. melanogaster</i>

Table III represents a variety of flea HNC nucleic acid molecules of the present invention.

Table III

SEQ ID NO:	Name
567	2096-19NB.HNC
568	2096-25NB.HNC
569	2096-48NB.HNC
570	2096-50NB.HNC
571	2096-52NB.HNC
572	2096-55NB.HNC
573	2097-09NB.HNC
574	2097-15NB.HNC
575	2097-20NB.HNC
576	2097-22NB.HNC
577	2097-32NB.HNC
578	2097-45NB.HNC
579	2097-46NB.HNC
580	2097-47NB.HNC
581	2097-56NB.HNC
582	2097-64NB.HNC
583	2098-04NB.HNC
584	2098-40NB.HNC
585	2098-43NB.HNC
586	2099-9NB.HNC
587	2100-10NB.HNC
588	2100-45NB.HNC
589	2100-47NB.HNC
590	2100-56NB.HNC
591	2100-63NB.HNC
592	2110-41NB.HNC
593	2110-53NB.HNC
594	2112-12NB.HNC
595	2112-35NB.HNC
596	2113-17NB.HNC
597	2115-16NB.HNC
598	2115-22NB.HNC
599	2115-3NB.HNC
600	2116-19NB.HNC

SEQ ID NO:	Name
601	2116-24NB.HNC
602	2116-27NB.HNC
603	2116-41NB.HNC
604	2116-59NB.HNC
605	2116-64NB.HNC
606	2117-05NB.HNC
607	2117-09NB.HNC
608	2117-11NB.HNC
609	2117-53NB.HNC
610	2118-03NB.HNC
611	2122-39NB.HNC
612	2123-25NB.HNC
613	2124-40NB.HNC
614	2124-62NB.HNC
615	2131-22NB.HNC
616	2131-32NB.HNC
617	2132-15NB.HNC
618	2132-28NB.HNC
619	2132-63NB.HNC
620	2132-9NB.HNC
621	2137-19NB.HNC
622	2137-24NB.HNC
623	2138-05NB.HNC
624	2138-51NB.HNC
625	2139-31NB.HNC
626	2139-41NB.HNC
627	2139-60NB.HNC
628	2140-13NB.HNC
629	2140-15NB.HNC
630	2140-18NB.HNC
631	2140-54NB.HNC
632	2141-16NB.HNC
633	2141-59NB.HNC
634	2142-16NB.HNC





Table III (cont'd)

SEQ ID NO.	Name
713	2186-45NB.HNC
714	2186-50NB.HNC
715	2186-52NB.HNC
716	2186-60NB.HNC
717	2186-62NB.HNC
718	2186-63NB.HNC
719	2186-68NB.HNC
720	2186-69NB.HNC
721	2211-19NB.HNC
722	2211-23NB.HNC
723	2211-29NB.HNC
724	2211-30NB.HNC
725	2211-43NB.HNC
726	2211-52NB.HNC
727	2211-64NB.HNC
728	2212-30NB.HNC
729	2212-31NB.HNC
730	2212-71NB.HNC
731	2212-72NB.HNC
732	2212-73NB.HNC
733	2212-81NB.HNC
734	2212-85NB.HNC
735	2212-87NB.HNC
736	2212-91NB.HNC
737	2212-96NB.HNC
738	2212-9NB.HNC
739	2213-08NB.HNC
740	2213-09NB.HNC
741	2213-11NB.HNC
742	2213-12NB.HNC
743	2213-18NB.HNC
744	2213-34NB.HNC
745	2213-53NB.HNC
746	2213-58NB.HNC
747	2213-67NB.HNC
748	2213-79NB.HNC
749	2214-02NB.HNC
750	2214-03NB.HNC
751	2214-05NB.HNC

SEQ ID NO.	Name
752	2214-07NB.HNC
753	2214-15NB.HNC
754	2214-23NB.HNC
755	2214-30NB.HNC
756	2214-36NB.HNC
757	2214-37NB.HNC
758	2214-40NB.HNC
759	2214-43NB.HNC
760	2214-53NB.HNC
761	2214-57NB.HNC
762	2214-60NB.HNC
763	2214-61NB.HNC
764	2214-73NB.HNC
765	2214-76NB.HNC
766	2214-80NB.HNC
767	2215-07NB.HNC
768	2215-15NB.HNC
769	2215-31NB.HNC
770	2215-41NB.HNC
771	2215-51NB.HNC
772	2215-80NB.HNC
773	2215-85NB.HNC
774	2215-91NB.HNC
775	2217-14NB.HNC
776	2217-16NB.HNC
777	2217-33NB.HNC
778	2217-39NB.HNC
779	2217-78NB.HNC
780	2217-92NB.HNC
781	2218-15NB.HNC
782	2218-19NB.HNC
783	2218-26NB.HNC
784	2218-36NB.HNC
785	2218-41NB.HNC
786	2218-56NB.HNC
787	2218-58NB.HNC
788	2218-69NB.HNC
789	2218-71NB.HNC
790	2218-76NB.HNC

Table III (cont'd)

SEQ ID NO:	Name
791	2218-77NB.HNC
792	2218-84NB.HNC
793	2218-96NB.HNC
794	2219-11NB.HNC
795	2219-13NB.HNC
796	2219-17NB.HNC
797	2219-19NB.HNC
798	2219-20NB.HNC
799	2219-22NB.HNC
800	2219-23NB.HNC
801	2219-32NB.HNC
802	2219-45NB.HNC
803	2219-49NB.HNC
804	2219-51NB.HNC
805	2219-72NB.HNC
806	2219-80NB.HNC
807	2219-952122-39NB.HNC
	2220-02NB.HNC
808	2220-02NB.HNC
809	2220-27NB.HNC
810	2220-32NB.HNC
811	2220-53NB.HNC
812	2220-60NB.HNC
813	2220-66NB.HNC
814	2221-06NB.HNC
815	2221-15NB.HNC
816	2221-18NB.HNC
817	2221-20NB.HNC
818	2221-24NB.HNC
819	2221-45NB.HNC
820	2221-46NB.HNC
821	2221-48NB.HNC
822	2221-54NB.HNC
823	2221-55NB.HNC
824	2221-59NB.HNC
825	2221-61NB.HNC
826	2221-62NB.HNC
827	2221-70NB.HNC
828	2221-86NB.HNC

SEQ ID NO:	Name
829	2221-87NB.HNC
830	2221-95NB.HNC
831	2223u-18NB.HNC
832	2223u-22NB.HNC
833	2223u-23NB.HNC
834	2223u-31NB.HNC
835	2223u-33NB.HNC
836	2223u-36NB.HNC
837	2223u-67NB.HNC
838	2223u-85NB.HNC
839	2224u-05NB.HNC
840	2224u-07NB.HNC
841	2224u-10NB.HNC
842	2224u-11NB.HNC
843	2224u-15NB.HNC
844	2224u-25NB.HNC
845	2224u-27NB.HNC
846	2224u-44NB.HNC
847	2224u-52NB.HNC
848	2224u-62NB.HNC
849	2224u-70NB.HNC
850	2224u-71NB.HNC
851	2224u-79NB.HNC
852	2225u-11NB.HNC
853	2225u-20NB.HNC
854	2225u-23NB.HNC
855	2225u-28NB.HNC
856	2225u-55NB.HNC
857	2225u-59NB.HNC
858	2225u-64NB.HNC
859	2225u-77NB.HNC
860	2225u-95NB.HNC
861	2226-932122-39NB.HNC
862	2226u-07NB.HNC
863	2226u-19NB.HNC
864	2226u-39NB.HNC
865	2226u-45NB.HNC
866	2226u-49NB.HNC

Table III (cont'd)

FC-6-C1

SEQ ID NO:	Name
867	2226u-54NB.HNC
868	2226u-71NB.HNC
869	2226u-77NB.HNC
870	2226u-83NB.HNC
871	2226u-91NB.HNC
872	2227u-12NB.HNC
873	2227u-13NB.HNC
874	2227u-23NB.HNC
875	2227u-26NB.HNC
876	2227u-30NB.HNC
877	2227u-31NB.HNC
878	2227u-33NB.HNC
879	2227u-43NB.HNC
880	2227u-51NB.HNC
881	2227u-60NB.HNC
882	2227u-93NB.HNC
883	2228u-04NB.HNC
884	2228u-09NB.HNC
885	2228u-12NB.HNC
886	2228u-21NB.HNC
887	2228u-26NB.HNC
888	2228u-49NB.HNC
889	2228u-54NB.HNC
890	2228u-55NB.HNC
891	2228u-61NB.HNC
892	2228u-65NB.HNC
893	2228u-79NB.HNC
894	2228u-90NB.HNC
1624	2222-7
1625	2222-16
1626	2222-19
1627	2222-39
1628	2222-56
1629	2222-59
1630	2222-79
1631	2222-89
1632	2228-4
1633	2228-9
1634	2228-12
1635	2228-21
1636	2228-26
1637	2228-49

SEQ ID NO:	Name
1638	2228-54
1639	2228-61
1640	2228-65
1641	2228-79
1642	2228-90
1643	2245-5
1644	2245-7
1645	2245-15
1646	2245-16
1647	2245-17
1648	2245-20
1649	2245-35
1650	2245-38
1651	2245-39
1652	2245-51
1653	2245-52
1654	2245-57
1655	2246-13
1656	2246-19
1657	2246-25
1658	2246-27
1659	2246-29
1660	2246-40
1661	2246-45
1662	2246-52
1663	2246-64
1664	2246-66
1665	2246-74
1666	2246-82
1667	2247-6
1668	2247-17
1669	2247-29
1670	2247-31
1671	2247-36
1672	2247-40
1673	2247-46
1674	2247-50
1675	2247-54
1676	2247-63
1677	2247-66
1678	2247-68
1679	2247-69
1680	2247-81
1681	2247-82
1682	2247-95
1683	2248-7

Table III (cont'd)

SEQ ID NO:	Name
1684	2248-18
1685	2248-32
1686	2248-41
1687	2248-50
1688	2248-54
1689	2248-60
1690	2248-62
1691	2248-65
1692	2248-86
1693	2248-94
1694	2249-6
1695	2249-30
1696	2249-35
1697	2249-36
1698	2249-68
1699	2249-74
1700	2249-79
1701	2250-20
1702	2250-24
1703	2251-7
1704	2251-21
1705	2251-25
1706	2251-38
1707	2251-58
1708	2252-7
1709	2252-15
1710	2252-19
1711	2252-24
1712	2252-26
1713	2252-27
1714	2252-32
1715	2252-36
1716	2252-37
1717	2252-69
1718	2252-78

09091936 112101  
TOTAL 98515660

Table IV represents a variety of flea HMT nucleic acid molecules of the present invention.

Table IV

SEQ ID NO:	Name
895	2084-02.HMTNB
896	2084-05.HMTNB
897	2084-07.HMTNB
898	2084-09.HMTNB
899	2084-15.HMTNB
900	2084-17.HMTNB
901	2084-18.HMTNB
902	2084-21.HMTNB
903	2084-22.HMTNB
904	2084-30.HMTNB
905	2084-33.HMTNB
906	2084-36.HMTNB
907	2084-37.HMTNB
908	2084-38.HMTNB
909	2084-39.HMTNB
910	2084-43.HMTNB
911	2084-50.HMTNB
912	2084-54.HMTNB
913	2084-56.HMTNB
914	2084-59.HMTNB
915	2085-03.HMTNB
916	2085-13.HMTNB
917	2085-35.HMTNB
918	2085-38.HMTNB
919	2085-39.HMTNB
920	2085-49.HMTNB
921	2085-53.HMTNB
922	2085-58.HMTNB
923	2085-61.HMTNB
924	2086-05.HMTNB
925	2086-10.HMTNB
926	2086-13.HMTNB
927	2086-15.HMTNB
928	2086-20.HMTNB
929	2086-25.HMTNB
930	2086-32.HMTNB
931	2086-33.HMTNB
932	2086-34.HMTNB
933	2086-37.HMTNB
934	2086-41.HMTNB
935	2086-43.HMTNB

SEQ ID NO:	Name
936	2086-44.HMTNB
937	2086-54.HMTNB
938	2086-55.HMTNB
939	2086-58.HMTNB
940	2087-09.HMTNB
941	2087-17.HMTNB
942	2087-28.HMTNB
943	2087-33.HMTNB
944	2087-35.HMTNB
945	2087-51.HMTNB
946	2087-54.HMTNB
947	2088-07.HMTNB
948	2088-17.HMTNB
949	2088-35.HMTNB
950	2088-52.HMTNB
951	2088-59.HMTNB
952	2089-12.HMTNB
953	2089-14.HMTNB
954	2089-33.HMTNB
955	2089-36.HMTNB
956	2089-51.HMTNB
957	2089-60.HMTNB
958	2090-11.HMTNB
959	2090-27.HMTNB
960	2090-33.HMTNB
961	2090-44.HMTNB
962	2090-57.HMTNB
963	2091-11.HMTNB
964	2091-22.HMTNB
965	2091-23.HMTNB
966	2091-35.HMTNB
967	2091-63.HMTNB
968	2092-11.HMTNB
969	2092-16.HMTNB
970	2092-40.HMTNB
971	2092-42.HMTNB
972	2092-46.HMTNB
973	2092-60.HMTNB
974	2093-20.HMTNB
975	2093-23.HMTNB
976	2093-43.HMTNB

Table IV (cont'd)

FC-6-C1

SEQ ID NO.	Name
977	2093-48.HMTNB
978	2093-50.HMTNB
979	2093-62.HMTNB
980	2093-63.HMTNB
981	2094-08.HMTNB
982	2094-26.HMTNB
983	2094-33.HMTNB
984	2094-47.HMTNB
985	2094-50.HMTNB
986	2094-62.HMTNB
987	2095-04.HMTNB
988	2095-10.HMTNB
989	2095-12.HMTNB
990	2095-13.HMTNB
991	2095-15.HMTNB
992	2095-20.HMTNB
993	2095-22.HMTNB
994	2095-31.HMTNB
995	2095-33.HMTNB
996	2095-34.HMTNB
997	2095-36.HMTNB
998	2095-40.HMTNB
999	2095-48.HMTNB
1000	2102-12.HMTNB
1001	2102-16.HMTNB
1002	2102-18.HMTNB
1003	2102-19.HMTNB
1004	2102-20.HMTNB
1005	2102-29.HMTNB
1006	2102-35.HMTNB
1007	2102-37.HMTNB
1008	2102-38.HMTNB
1009	2102-41.HMTNB
1010	2102-47.HMTNB
1011	2103-02.HMTNB
1012	2103-09.HMTNB
1013	2103-45.HMTNB
1014	2103-56.HMTNB
1015	2103-58.HMTNB
1016	2104-58.HMTNB
1017	2104-60.HMTNB
1018	2104-61.HMTNB
1019	2105-02.HMTNB
1020	2105-20.HMTNB
1021	2105-35.HMTNB
1022	2105-42.HMTNB
1023	2105-44.HMTNB
1024	2106-05.HMTNB

SEQ ID NO.	Nam
1025	2106-27.HMTNB
1026	2106-29.HMTNB
1027	2106-34.HMTNB
1028	2106-48.HMTNB
1029	2106-50.HMTNB
1030	2106-64.HMTNB
1031	2107-02.HMTNB
1032	2107-10.HMTNB
1033	2107-37.HMTNB
1034	2108-03.HMTNB
1035	2108-23.HMTNB
1036	2108-46.HMTNB
1037	2108-47.HMTNB
1038	2108-48.HMTNB
1039	2108-49.HMTNB
1040	2108-63.HMTNB
1041	2109-04.HMTNB
1042	2109-06.HMTNB
1043	2109-37.HMTNB
1044	2109-38.HMTNB
1045	2109-44.HMTNB
1046	2154-08.HMTNB
1047	2154-09.HMTNB
1048	2154-10.HMTNB
1049	2154-28.HMTNB
1050	2154-30.HMTNB
1051	2154-45.HMTNB
1052	2154-46.HMTNB
1053	2154-61.HMTNB
1054	2154-71.HMTNB
1055	2154-81.HMTNB
1056	2154-83.HMTNB
1057	2156-02.HMTNB
1058	2156-06.HMTNB
1059	2156-18.HMTNB
1060	2156-27.HMTNB
1061	2156-43.HMTNB
1062	2156-48.HMTNB
1063	2156-50.HMTNB
1064	2157-16.HMTNB
1065	2157-34.HMTNB
1066	2157-45.HMTNB
1067	2157-70.HMTNB
1068	2157-75.HMTNB
1069	2157-79.HMTNB
1070	2157-86.HMTNB
1071	2158-02.HMTNB
1072	2158-14.HMTNB

Table IV (cont'd)

SEQ ID NO.	Name
1073	2158-19.HMTNB
1074	2158-22.HMTNB
1075	2158-27.HMTNB
1076	2158-34.HMTNB
1077	2158-37.HMTNB
1078	2158-39.HMTNB
1079	2159-07.HMTNB
1080	2159-09.HMTNB
1081	2159-17.HMTNB
1082	2159-34.HMTNB
1083	2159-35.HMTNB
1084	2159-60.HMTNB
1085	2160-16.HMTNB
1086	2160-17.HMTNB
1087	2160-29.HMTNB
1088	2160-30.HMTNB
1089	2160-32.HMTNB
1090	2160-39.HMTNB
1091	2160-49.HMTNB
1092	2160-53.HMTNB
1093	2160-54.HMTNB
1094	2160-55.HMTNB
1095	2160-77.HMTNB
1096	2160-82.HMTNB
1097	2160-89.HMTNB
1098	2160-91.HMTNB
1099	2161-13.HMTNB
1100	2161-19.HMTNB
1101	2161-45.HMTNB
1102	2161-57.HMTNB
1103	2161-60.HMTNB
1104	2161-79.HMTNB
1105	2161-83.HMTNB
1106	2161-90.HMTNB
1107	2161-94.HMTNB
1108	2162-05.HMTNB
1109	2162-12.HMTNB
1110	2162-13.HMTNB
1111	2162-18.HMTNB
1112	2162-35.HMTNB
1113	2162-41.HMTNB
1114	2162-50.HMTNB
1115	2162-59.HMTNB
1116	2162-63.HMTNB
1117	2162-71.HMTNB
1118	2162-75.HMTNB
1119	2162-78.HMTNB
1120	2163-07.HMTNB

SEQ ID NO.	Name
1121	2163-11.HMTNB
1122	2163-18.HMTNB
1123	2163-23.HMTNB
1124	2163-25.HMTNB
1125	2163-43.HMTNB
1126	2163-50.HMTNB
1127	2163-61.HMTNB
1128	2163-65.HMTNB
1129	2163-73.HMTNB
1130	2163-77.HMTNB
1131	2163-87.HMTNB
1132	2163-93.HMTNB
1133	2163-95.HMTNB
1134	2165-04.HMTNB
1135	2165-06.HMTNB
1136	2165-24.HMTNB
1137	2165-45.HMTNB
1138	2165-59.HMTNB
1139	2165-65.HMTNB
1140	2166-02.HMTNB
1141	2166-12.HMTNB
1142	2166-42.HMTNB
1143	2166-46.HMTNB
1144	2166-47.HMTNB
1145	2167-07.HMTNB
1146	2167-16.HMTNB
1147	2167-42.HMTNB
1148	2167-65.HMTNB
1149	2167-66.HMTNB
1150	2167-79.HMTNB
1151	2167-90.HMTNB
1152	2167-94.HMTNB
1153	2169-05.HMTNB
1154	2169-12.HMTNB
1155	2169-16.HMTNB
1156	2169-17.HMTNB
1157	2169-19.HMTNB
1158	2169-22.HMTNB
1159	2169-26.HMTNB
1160	2169-33.HMTNB
1161	2169-42.HMTNB
1162	2169-46.HMTNB
1163	2169-47.HMTNB
1164	2169-57.HMTNB
1165	2169-69.HMTNB
1166	2171-06.HMTNB
1167	2171-09.HMTNB
1168	2171-11.HMTNB

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Table IV (cont'd)

SEQ ID NO	Name
1169	2171-29.HMTNB
1170	2171-33.HMTNB
1171	2171-35.HMTNB
1172	2171-41.HMTNB
1173	2171-54.HMTNB
1174	2171-57.HMTNB
1175	2171-69.HMTNB
1176	2171-82.HMTNB
1177	2171-84.HMTNB
1178	2171-85.HMTNB
1179	2173-12.HMTNB
1180	2173-34.HMTNB
1181	2173-42.HMTNB
1182	2173-48.HMTNB
1183	2173-54.HMTNB
1184	2173-57.HMTNB
1185	2173-75.HMTNB
1186	2173-86.HMTNB
1187	2173-91.HMTNB
1188	2175-06.HMTNB
1189	2175-15.HMTNB
1190	2175-20.HMTNB
1191	2175-58.HMTNB
1192	2175-96.HMTNB
1193	2177-16.HMTNB
1194	2177-70.HMTNB
1195	2177-86.HMTNB
1196	2179-02.HMTNB
1197	2179-03.HMTNB
1198	2179-19.HMTNB
1199	2179-22.HMTNB
1200	2179-29.HMTNB
1201	2179-39.HMTNB
1202	2179-63.HMTNB
1203	2181-04.HMTNB
1204	2181-24.HMTNB
1205	2181-35.HMTNB
1206	2181-66.HMTNB
1207	2181-75.HMTNB
1208	2181-76.HMTNB
1209	2181-84.HMTNB
1210	2183-05.HMTNB
1211	2183-13.HMTNB
1212	2183-17.HMTNB
1213	2183-28.HMTNB
1214	2183-45.HMTNB
1215	2183-50.HMTNB
1216	2183-51.HMTNB

SEQ ID NO	Name
1217	2183-70.HMTNB
1218	2185-05.HMTNB
1219	2185-10.HMTNB
1220	2185-12.HMTNB
1221	2185-18.HMTNB
1222	2185-43.HMTNB
1223	2185-49.HMTNB
1224	2185-54.HMTNB
1225	2185-82.HMTNB
1226	2187-21.HMTNB
1227	2187-37.HMTNB
1228	2187-47.HMTNB
1229	2187-93.HMTNB
1230	2188-22.HMTNB
1231	2188-29.HMTNB
1232	2188-32.HMTNB
1233	2188-52.HMTNB
1234	2188-54.HMTNB
1235	2188-72.HMTNB
1236	2188-92.HMTNB
1237	2189-31.HMTNB
1238	2189-56.HMTNB
1239	2189-75.HMTNB
1240	2189-84.HMTNB
1241	2191-23.HMTNB
1242	2191-38.HMTNB
1243	2191-58.HMTNB
1244	2191-73.HMTNB
1245	2191-77.HMTNB
1246	2191-90.HMTNB
1247	2191-94.HMTNB
1248	2191-96.HMTNB
1249	2192-03.HMTNB
1250	2192-14.HMTNB
1251	2192-36.HMTNB
1252	2192-46.HMTNB
1253	2192-88.HMTNB
1254	2194-07.HMTNB
1255	2194-13.HMTNB
1256	2194-16.HMTNB
1257	2194-18.HMTNB
1258	2194-28.HMTNB
1259	2195-06.HMTNB
1260	2195-47.HMTNB
1261	2195-60.HMTNB
1262	2196-18.HMTNB
1263	2196-30.HMTNB
1264	2196-53.HMTNB

TOTAL = 926

Table IV (cont'd)

SEQ ID NO:	Name
1265	2196-65.HMTNB
1266	2196-76.HMTNB
1267	2197-28.HMTNB
1268	2197-46.HMTNB
1269	2197-51.HMTNB
1270	2197-59.HMTNB
1271	2202-96.HMTNB
1272	2203-36.HMTNB
1273	2204-09.HMTNB
1274	2205-11.HMTNB
1275	2205-33.HMTNB
1276	2205-43.HMTNB
1277	2205-85.HMTNB
1278	2229-08u.HMTNB
1279	2229-10u.HMTNB
1280	2229-12u.HMTNB
1281	2229-14u.HMTNB
1282	2229-27u.HMTNB
1283	2229-40u.HMTNB
1284	2229-45u.HMTNB
1285	2229-48u.HMTNB
1286	2229-50u.HMTNB
1287	2229-54u.HMTNB
1288	2229-56u.HMTNB
1289	2229-57u.HMTNB
1290	2229-59u.HMTNB
1291	2229-70u.HMTNB
1292	2229-87u.HMTNB
1293	2229-91u.HMTNB
1294	2229-95u.HMTNB
1295	2230-07u.HMTNB
1296	2230-11u.HMTNB
1297	2230-19u.HMTNB
1298	2230-27u.HMTNB
1299	2230-33u.HMTNB
1300	2230-41u.HMTNB
1301	2230-51u.HMTNB
1302	2230-56u.HMTNB
1303	2230-66u.HMTNB
1304	2230-71u.HMTNB
1305	2230-75.HMTNB
1306	2230-81u.HMTNB
1307	2230-84u.HMTNB
1308	2230-93u.HMTNB
1309	2231-23u.HMTNB
1310	2231-26u.HMTNB
1311	2231-32u.HMTNB
1312	2231-37u.HMTNB

SEQ ID NO:	Name
1313	2231-44u.HMTNB
1314	2231-50u.HMTNB
1315	2231-51u.HMTNB
1316	2231-63u.HMTNB
1317	2231-68u.HMTNB
1318	2231-74u.HMTNB
1319	2231-82u.HMTNB
1320	2231-85u.HMTNB
1321	2231-88u.HMTNB
1322	2231-94u.HMTNB
1323	2231-95u.HMTNB
1324	2232-03u.HMTNB
1325	2232-11u.HMTNB
1326	2232-19u.HMTNB
1327	2232-25u.HMTNB
1328	2232-30u.HMTNB
1329	2232-44u.HMTNB
1330	2232-50u.HMTNB
1331	2232-56u.HMTNB
1332	2232-60u.HMTNB
1333	2232-64u.HMTNB
1334	2232-71u.HMTNB
1335	2232-73u.HMTNB
1336	2232-80u.HMTNB
1337	2232-83u.HMTNB
1338	2233-02u.HMTNB
1339	2233-53u.HMTNB
1340	2233-57u.HMTNB
1341	2233-58u.HMTNB
1342	2233-80u.HMTNB
1343	2233-81u.HMTNB
1344	2233-83u.HMTNB
1345	2234-02u.HMTNB
1346	2234-03u.HMTNB
1347	2234-05u.HMTNB
1348	2234-06u.HMTNB
1349	2234-09u.HMTNB
1350	2234-12u.HMTNB
1351	2234-23u.HMTNB
1352	2234-26u.HMTNB
1353	2234-46u.HMTNB
1354	2234-66u.HMTNB
1355	2234-67u.HMTNB
1356	2234-70u.HMTNB
1357	2234-74u.HMTNB
1358	2234-77u.HMTNB
1359	2234-82u.HMTNB
1360	2234-88u.HMTNB

Table IV (cont'd)

SEQ ID NO:	Name
1361	2234-89u.HMTNB
1362	2234-90u.HMTNB
1363	2234-93u.HMTNB
1364	2240-39
1365	2240-40
1366	2240-49
1367	2240-51
1368	2240-57
1369	2240-61
1370	2240-62
1371	2241-2
1372	2241-3
1373	2241-8
1374	2241-9
1375	2241-13
1376	2241-21
1377	2241-29
1378	2241-38
1379	2241-45
1380	2241-49
1381	2241-51
1382	2241-57
1383	2241-63
1384	2241-68
1385	2241-89
1386	2241-91
1387	2243-2
1388	2243-3
1389	2243-12
1390	2243-14
1391	2243-19
1392	2243-24
1393	2243-25
1394	2243-33
1395	2243-49
1396	2243-50
1397	2243-51
1398	2243-59
1399	2243-63
1400	2243-69
1401	2243-74
1402	2243-75
1403	2243-77
1404	2244-19
1405	2244-26
1406	2244-35
1407	2244-38
1408	2244-40

SEQ ID NO:	Name
1409	2244-47
1410	2244-52
1411	2244-57
1412	2244-63
1413	2244-68
1414	2244-77
1415	2244-80

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In one embodiment, a gene or other nucleic acid molecule of the present invention can be an allelic variant that includes a similar but not identical sequence to SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:16, SEQ ID NO:18, SEQ ID NO:19, SEQ ID NO:21, SEQ ID NO:22, SEQ ID NO:24, SEQ ID NO:25, SEQ ID NO:27, SEQ ID NO:28, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:33, SEQ ID NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45, SEQ ID NO:46, SEQ ID NO:48, SEQ ID NO:153, SEQ ID NO:155, SEQ ID NO:156, SEQ ID NO:158, SEQ ID NO:159, SEQ ID NO:161, SEQ ID NO:162, SEQ ID NO:164, SEQ ID NO:165, SEQ ID NO:167, SEQ ID NO:168, SEQ ID NO:170, SEQ ID NO:1859, SEQ ID NO:1860, SEQ ID NO:1861, SEQ ID NO:1863, SEQ ID NO:1864, SEQ ID NO:1866, SEQ ID NO:1867, SEQ ID NO:1869, SEQ ID NO:1870, SEQ ID NO:1871, SEQ ID NO:1872, SEQ ID NO:1874, SEQ ID NO:1875, SEQ ID NO:1876, SEQ ID NO:1877, SEQ ID NO:1878, SEQ ID NO:1880, SEQ ID NO:1881, SEQ ID NO:1882, SEQ ID NO:1884, SEQ ID NO:1885, SEQ ID NO:1886, SEQ ID NO:1887, SEQ ID NO:1889, SEQ ID NO:1890, SEQ ID NO:1891, SEQ ID NO:1892, SEQ ID NO:1893, SEQ ID NO:1894, SEQ ID NO:1895, SEQ ID NO:1896, SEQ ID NO:1898, SEQ ID NO:1899, SEQ ID NO:1900, SEQ ID NO:1901, SEQ ID NO:1903, SEQ ID NO:1904, SEQ ID NO:1905, SEQ ID NO:1906, SEQ ID NO:1907, SEQ ID NO:1908, SEQ ID NO:1909, SEQ ID NO:1910, SEQ ID NO:1911, SEQ ID NO:1912, SEQ ID NO:1913, SEQ ID NO:1914, SEQ ID NO:1916, SEQ ID NO:1917, SEQ ID NO:1918, SEQ ID NO:1919, SEQ ID NO:1921,

SEQ ID NO:1922, SEQ ID NO:1923, SEQ ID NO:1924, SEQ ID NO:1926, SEQ ID NO:1927, SEQ ID NO:1928, SEQ ID NO:1929, and/or SEQ ID NO:1931 or a *C. felis* nucleic acid sequence of Table I, Table II, Table III and/or Table IV or a complement thereof. For example, an allelic variant of a *C. felis* ALN gene including SEQ ID NO:1 is

5 a gene that occurs at essentially the same locus (or loci) in the genome as the gene including SEQ ID NO:1, but which, due to natural variations caused by, for example, mutation or recombination, has a similar but not identical sequence. Because natural selection typically selects against alterations that affect function, allelic variants (i.e. alleles corresponding to, or of, cited nucleic acid sequences) usually encode proteins

10 having similar activity to that of the protein encoded by the gene to which they are being compared. Allelic variants of genes or nucleic acid molecules can also comprise alterations in the 5' or 3' untranslated regions of the gene (e.g., in regulatory control regions), or can involve alternative splicing of a nascent transcript, thereby bringing alternative exons into juxtaposition. Allelic variants are well known to those skilled in

15 the art and would be expected to occur naturally within a given flea such as *C. felis*, since the genome is diploid, and sexual reproduction will result in the reassortment of alleles. For example, SEQ ID NO:162 is apparently an allelic variant or multiple gene of SEQ ID NO:153.

In one embodiment of the present invention, isolated HMT and HNC proteins are

20 encoded by nucleic acid molecules that hybridize under stringent hybridization conditions to genes or other nucleic acid molecules encoding flea HMT and HNC proteins, respectively. The minimal size of HMT and HNC proteins of the present invention is a

size sufficient to be encoded by a nucleic acid molecule capable of forming a stable hybrid (i.e., hybridizing under stringent hybridization conditions) with the complementary sequence of a nucleic acid molecule encoding the corresponding natural protein. The size of a nucleic acid molecule encoding such a protein is dependent on the nucleic acid composition and the percent homology between the flea HMT or HNC nucleic acid molecule and the complementary nucleic acid sequence. It can easily be understood that the extent of homology required to form a stable hybrid under stringent conditions can vary depending on whether the homologous sequences are interspersed throughout a given nucleic acid molecule or are clustered (i.e., localized) in distinct regions on a given nucleic acid molecule.

The minimal size of a nucleic acid molecule capable of forming a stable hybrid with a gene encoding a flea HMT or HNC protein is typically at least about 12 to about 15 nucleotides in length if the nucleic acid molecule is GC-rich and at least about 15 to about 17 bases in length if it is AT-rich. The minimal size of a nucleic acid molecule used to encode an HMT or HNC protein homologue of the present invention is from about 12 to about 18 nucleotides in length. Thus, the minimal size of HMT or HNC protein homologues of the present invention is from about 4 to about 6 amino acids in length. There is no limit, other than a practical limit, on the maximal size of a nucleic acid molecule encoding a flea HMT or HNC protein of the present invention because a nucleic acid molecule of the present invention can include a portion of a gene, an entire gene, or multiple genes. The preferred size of a protein encoded by a nucleic acid

molecule of the present invention depends on whether a full-length, fusion, multivalent, or functional portion of such a protein is desired.

Stringent hybridization conditions are determined based on defined physical properties of the gene to which the nucleic acid molecule is being hybridized, and can be defined mathematically. Stringent hybridization conditions are those experimental parameters that allow an individual skilled in the art to identify significant similarities between heterologous nucleic acid molecules. These conditions are well known to those skilled in the art. See, for example, Sambrook, *et al.*, 1989, *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor Labs Press, and Meinkoth, *et al.*, 1984, *Anal. Biochem.* 138, 267-284, each of which is incorporated by reference herein in its entirety. As explained in detail in the cited references, the determination of hybridization conditions involves the manipulation of a set of variables including the ionic strength (M, in moles/liter), the hybridization temperature (°C), the concentration of nucleic acid helix destabilizing agents (such as formamide), the average length of the shortest hybrid duplex (n), and the percent G + C composition of the fragment to which an unknown nucleic acid molecule is being hybridized. For nucleic acid molecules of at least about 150 nucleotides, these variables are inserted into a standard mathematical formula to calculate the melting temperature, or  $T_m$ , of a given nucleic acid molecule. As defined in the formula below,  $T_m$  is the temperature at which two complementary nucleic acid molecule strands will disassociate, assuming 100% complementarity between the two strands:

$$T_m = 81.5^{\circ}\text{C} + 16.6 \log M + 0.41(\%G + C) - 500/n - 0.61(\%\text{formamide}).$$

For nucleic acid molecules smaller than about 50 nucleotides, hybrid stability is defined by the dissociation temperature ( $T_d$ ), which is defined as the temperature at which 50% of the duplexes dissociate. For these smaller molecules, the stability at a standard ionic strength is defined by the following equation:

$$T_d = 4(G + C) + 2(A + T).$$

A temperature of 5°C below  $T_d$  is used to detect hybridization between perfectly matched molecules.

Also well known to those skilled in the art is how base pair mismatch, i.e. differences between two nucleic acid molecules being compared, including non-complementarity of bases at a given location, and gaps due to insertion or deletion of one or more bases at a given location on either of the nucleic acid molecules being compared, will affect  $T_m$  or  $T_d$  for nucleic acid molecules of different sizes. For example,  $T_m$  decreases about 1°C for each 1% of mismatched base pairs for hybrids greater than about 150 bp, and  $T_d$  decreases about 5°C for each mismatched base pair for hybrids below about 50 bp. Conditions for hybrids between about 50 and about 150 base pairs can be determined empirically and without undue experimentation using standard laboratory procedures well known to those skilled in the art. These simple procedures allow one skilled in the art to set the hybridization conditions (by altering, for example, the salt concentration, the formamide concentration or the temperature) so that only nucleic acid hybrids with greater than a specified % base pair mismatch will hybridize. Stringent hybridization conditions are commonly understood by those skilled in the art to be those experimental conditions that will allow less than or equal to about 30% base pair



mismatch (i.e., at least about 70% identity). Because one skilled in the art can easily determine whether a given nucleic acid molecule to be tested is less than or greater than about 50 nucleotides, and can therefore choose the appropriate formula for determining hybridization conditions, he or she can determine whether the nucleic acid molecule will  
 5 hybridize with a given gene under stringent hybridization conditions and similarly whether the nucleic acid molecule will hybridize under conditions designed to allow a desired amount of base pair mismatch.

Hybridization reactions are often carried out by attaching the nucleic acid molecule to be hybridized to a solid support such as a membrane, and then hybridizing  
 10 with a labeled nucleic acid molecule, typically referred to as a probe, suspended in a hybridization solution. Examples of common hybridization reaction techniques include, but are not limited to, the well-known Southern and northern blotting procedures. Typically, the actual hybridization reaction is done under non-stringent conditions, i.e., at a lower temperature and/or a higher salt concentration, and then high stringency is  
 15 achieved by washing the membrane in a solution with a higher temperature and/or lower salt concentration in order to achieve the desired stringency.

For example, if the skilled artisan wished to identify a nucleic acid molecule that hybridizes under conditions that would allow less than or equal to 30% pair mismatch with a flea nucleic acid molecule of about 150 bp in length or greater, the following  
 20 conditions could preferably be used. The average G + C content of flea DNA is about 37%, as calculated from known flea nucleic acid sequences. The unknown nucleic acid molecules would be attached to a support membrane, and the 150 bp probe would be labeled, e.g. with a radioactive tag. The hybridization reaction could be carried out in a

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solution comprising 2X SSC and 0% formamide, at a temperature of about 37°C (low stringency conditions). Solutions of differing concentrations of SSC can be made by one of skill in the art by diluting a stock solution of 20X SSC (175.3 gram NaCl and about 88.2 gram sodium citrate in 1 liter of water, pH 7) to obtain the desired concentration of

5 SSC. The skilled artisan would calculate the washing conditions required to allow up to 30% base pair mismatch. For example, in a wash solution comprising 1X SSC and 0% formamide, the  $T_m$  of perfect hybrids would be about 77°C:

$$81.5^{\circ}\text{C} + 16.6 \log (.15\text{M}) + (0.41 \times 0.37) - (500/150) - (0.61 \times 0) = 77.5^{\circ}\text{C}.$$

Thus, to achieve hybridization with nucleic acid molecules having about 30% base pair

10 mismatch, hybridization washes would be carried out at a temperature of less than or equal to 47.5°C. It is thus within the skill of one in the art to calculate additional hybridization temperatures based on the desired percentage base pair mismatch, formulae and G/C content disclosed herein. For example, it is appreciated by one skilled in the art that as the nucleic acid molecule to be tested for hybridization against nucleic acid

15 molecules of the present invention having sequences specified herein becomes longer than 150 nucleotides, the  $T_m$  for a hybridization reaction allowing up to 30% base pair mismatch will not vary significantly from 47.5°C.

Furthermore, it is known in the art that there are commercially available computer programs for determining the degree of similarity between two nucleic acid sequences.

20 These computer programs include various known methods to determine the percentage identity and the number and length of gaps between hybrid nucleic acid molecules. Preferred methods to determine the percent identity among amino acid sequences and also among nucleic acid sequences include analysis using one or more of the

commercially available computer programs designed to compare and analyze nucleic acid or amino acid sequences. These computer programs include, but are not limited to, the Wisconsin Package Version 9.0 sequence analysis software, available from Genetics Computer Group (GCG™), Madison, WI, DNAsis™, available from Hitachi Software, San Bruno, CA, and MacVector™, available from the Eastman Kodak Company, New Haven, CT. A preferred method to determine percent identity among amino acid sequences and also among nucleic acid sequences includes using the GAP program with pair-wise comparisons within the GCG™ Wisconsin Package Version 9.0 sequence analysis software, hereinafter referred to as default parameters.

One embodiment of the present invention includes flea ALN, CBP, NKAB, LGIC, ANON, MALV, OS-D, NMDA, CLBP, NAH, CLIC, PL2, PL3, PL4, SVP, VGCC, AUP, and 7B2 proteins. A preferred flea ALN protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:3 and SEQ ID NO:6.

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A preferred flea CBP protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:9 and SEQ ID NO:12.

A preferred flea NKAB protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:15 and SEQ ID NO:18.

A preferred flea LGIC protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about

30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:21 and SEQ ID NO:24, SEQ ID NO:1860, SEQ ID NO:1863, and SEQ ID NO:1866.

A preferred flea ANON protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:27 and SEQ ID NO:30.

A preferred flea MALV protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than

or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a  
5 nucleic acid molecule selected from the group consisting of SEQ ID NO:33 and SEQ ID NO:36.

A preferred flea OS-D protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal  
10 to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a  
15 nucleic acid molecule selected from the group consisting of SEQ ID NO:39 and SEQ ID NO:42.

A preferred flea NMDA protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal  
20 to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions

that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:45 and SEQ ID NO:48.

5           A preferred flea CLBP protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow  
10 less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:155, SEQ ID NO:158, SEQ ID NO:161, SEQ ID NO:164, SEQ ID NO:167 and SEQ ID NO:170.

15           A preferred flea NAH protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow  
20 less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a

nucleic acid molecule selected from the group consisting of SEQ ID NO:1869 and SEQ ID NO:1871.

A preferred flea CLIC protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 5 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably 10 under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:1874 and SEQ ID NO:1876.

A preferred flea PL2 protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 15 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably 20 under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:1879, SEQ ID NO:1881, SEQ ID NO:1884, and SEQ ID NO:1886.



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A preferred flea CPL3 protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:1889 and SEQ ID NO:1891.

A preferred flea PL4 protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:1893, SEQ ID NO:1895, SEQ ID NO:1898, and SEQ ID NO:1900.

A preferred flea SVP protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about

30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:1903 and SEQ ID NO:1905.

A preferred flea VGCC protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:1907, SEQ ID NO:1909, SEQ ID NO:1911, SEQ ID NO:1913, SEQ ID NO:1916, and SEQ ID NO:1918.

A preferred flea AUP protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal

to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:1921 and SEQ ID NO:1923.

A preferred flea 7B2 protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of SEQ ID NO:1926, SEQ ID NO:1928, and SEQ ID NO:1931.

A preferred flea HMT and/or HNC protein includes a protein encoded by a nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20% base pair mismatch, more preferably under

conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule selected from the group consisting of a nucleic acid sequence complementary to a nucleic acid sequence of Table I, Table II, Table III  
5 and/or Table IV.

Another embodiment of the present invention includes a flea ALN protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of  
10 about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:3 and SEQ ID NO:6.

Another embodiment of the present invention includes a flea CBP protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a)  
15 hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:9 and SEQ ID NO:13.

Another embodiment of the present invention includes a flea NKAB protein  
20 encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a

temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:15 and SEQ ID NO:18.

Another embodiment of the present invention includes a flea LGIC protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:21, SEQ ID NO:24, SEQ ID NO:1860, SEQ ID NO:1863, and SEQ ID NO:1866.

Another embodiment of the present invention includes a flea ANON protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:27 and SEQ ID NO:30.

Another embodiment of the present invention includes a flea MALV protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:33 and SEQ ID NO:36.

Another embodiment of the present invention includes a flea OS-D protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:39 and SEQ ID NO:42.

Another embodiment of the present invention includes a flea NMDA protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:45 and SEQ ID NO:48.

Another embodiment of the present invention includes a flea CLBP protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:155, SEQ ID NO:158, SEQ ID NO:161, SEQ ID NO:164, SEQ ID NO:167 and SEQ ID NO:170.

Another embodiment of the present invention includes a flea NAH protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of

about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:1869 and SEQ ID NO:1871.

Another embodiment of the present invention includes a flea CLIC protein  
5 encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:1874 and SEQ ID NO:1876.

10 Another embodiment of the present invention includes a flea PL2 protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID  
15 NO:1879, SEQ ID NO:1881, SEQ ID NO:1884 and SEQ ID NO:1886.

Another embodiment of the present invention includes a flea PL3 protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about  
20 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:1889 and SEQ ID NO:1891.

Another embodiment of the present invention includes a flea PL4 protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:1893, SEQ ID NO:1895, SEQ ID NO:1898, and SEQ ID NO:1900.

Another embodiment of the present invention includes a flea SVP protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:1903 and SEQ ID NO:1905.

Another embodiment of the present invention includes a flea VGCC protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:1907, SEQ ID NO:1909, SEQ ID NO:1911, SEQ ID NO:1913, SEQ ID NO:1916, and SEQ ID NO:1918.

Another embodiment of the present invention includes a flea AUP protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of



about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:1921 and SEQ ID NO:1923.

Another embodiment of the present invention includes a flea 7B2 protein encoded  
 5 by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of SEQ ID NO:1926, SEQ ID NO:1928, and SEQ ID NO:1931.

10 Another embodiment of the present invention includes a flea HMT and/or HNC protein encoded by a nucleic acid molecule that hybridizes under conditions comprising, (a) hybridizing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 37°C and (b) washing in a solution comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated nucleic acid molecule selected from the group  
 15 consisting of a nucleic acid sequence complementary to a nucleic acid sequence of Table I, Table II, Table III and/or Table IV.

Another preferred flea ALN protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80%  
 20 identical, more preferably about at least 85% identical, more preferably about at least 90% identical, and even more preferably about at least 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:1 and/or SEQ ID NO:4; also

preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

- 5           Another preferred flea CBP protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably at least about 85% identical, more preferably at least about 90% identical, and even more preferably at least about 95% identical to a nucleic acid
- 10   molecule having the nucleic acid sequence SEQ ID NO:7 and/or SEQ ID NO:10; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.
- 15           Another preferred flea NKAB protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably at least about 85% identical, more preferably at least about 90% identical, and even more preferably at least about 95% identical to a nucleic acid
- 20   molecule having the nucleic acid sequence SEQ ID NO:13 and/or SEQ ID NO:16; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using

the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea LGIC protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably at least about 85% identical, more preferably at least about 90% identical, and even more preferably at least about 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:19, SEQ ID NO:22, SEQ ID NO:1861, and/or SEQ ID NO:1864; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea ANON protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably at least about 85% identical, more preferably at least about 90% identical, and even more preferably at least about 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:25 and/or SEQ ID NO:28; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea MALV protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably at least about 85% identical, more preferably at least about 90% identical, and even more preferably at least about 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:31 and/or SEQ ID NO:34; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea OS-D protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably at least about 85% identical, more preferably at least about 90% identical, and even more preferably at least about 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:37 and/or SEQ ID NO:40; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea NMDA protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical,

more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably at least about 85% identical, more preferably at least about 90% identical, and even more preferably at least about 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:43 and/or SEQ ID NO:46; also  
5 preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea CLBP protein of the present invention includes a protein  
10 that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably at least about 85% identical, more preferably at least about 90% identical, and even more preferably at least about 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:153, SEQ ID NO:156, SEQ ID  
15 NO:159, SEQ ID NO:162, SEQ ID NO:165 and/or SEQ ID NO:168; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

20 Another preferred flea NAH protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80%

identical, more preferably about at least 85% identical, more preferably about at least 90% identical, and even more preferably about at least 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:1867 and/or SEQ ID NO:1870; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea CLIC protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably about at least 85% identical, more preferably about at least 90% identical, and even more preferably about at least 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:1872 and/or SEQ ID NO:1875; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea PL2 protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably about at least 85% identical, more preferably about at least 90% identical, and even more preferably about at least 95% identical to a nucleic acid

5 molecule having the nucleic acid sequence SEQ ID NO:1877, SEQ ID NO:1878, SEQ ID NO:1880, SEQ ID NO:1882, and/or SEQ ID NO:1885; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea PL3 protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably about at least 85% identical, more preferably about at least 90% identical, and even more preferably about at least 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:1887 and/or SEQ ID NO:1890; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea PL4 protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably about at least 85% identical, more preferably about at least 90% identical, and even more preferably about at least 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:1892, SEQ ID NO:1894, SEQ ID NO:1896 and/or SEQ ID NO:1899; also preferred are fragments (i.e. portions) of such

proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea SVP protein of the present invention includes a protein that  
5 is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably about at least 85% identical, more preferably about at least 90% identical, and even more preferably about at least 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:1901 and/or SEQ ID NO:1904;  
10 also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea VGCC protein of the present invention includes a protein  
15 that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably about at least 85% identical, more preferably about at least 90% identical, and even more preferably about at least 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:1906, SEQ ID NO:1908, SEQ ID  
20 NO:1910, SEQ ID NO:1912, SEQ ID NO:1914 and/or SEQ ID NO:1917; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the



Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea AUP protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably about at least 85% identical, more preferably about at least 90% identical, and even more preferably about at least 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:1919 and/or SEQ ID NO:1922; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea 7B2 protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably about at least 85% identical, more preferably about at least 90% identical, and even more preferably about at least 95% identical to a nucleic acid molecule having the nucleic acid sequence SEQ ID NO:1924, SEQ ID NO:1927 and/or SEQ ID NO:1929; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Another preferred flea HMT and/or HNC protein of the present invention includes a protein that is encoded by a nucleic acid molecule that is preferably at least about 70% identical, more preferably at least about 75% identical, more preferably at least about 80% identical, more preferably at least about 85% identical, more preferably at least about 90% identical, and even more preferably at least about 95% identical to a nucleic acid molecule having a nucleic acid sequence of Table I, Table II, Table III and/or Table IV; also preferred are fragments (i.e. portions) of such proteins encoded by nucleic acid molecules that are at least about 18 nucleotides. Percent identity as used herein is determined using the Compare function by maximum matching within the program DNAsis Version 2.1 using default parameters.

Additional preferred flea ALN proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:2 or SEQ ID NO:5, and proteins comprising homologues of a protein having the amino acid sequence SEQ ID NO:2 or SEQ ID NO:5, wherein such a homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:2 or SEQ ID NO:5. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:1 and/or SEQ ID NO:4, or by homologues thereof.

Additional preferred flea CBP proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:8 or SEQ ID NO:11, and proteins comprising homologues of a protein having the amino acid sequence SEQ ID NO:8 or SEQ ID NO:11, wherein such a homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:8 or SEQ

ID NO:11. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:7 and/or SEQ ID NO:10, or by homologues thereof.

Additional preferred flea NKAB proteins of the present invention include proteins  
5 having the amino acid sequence SEQ ID NO:14 or SEQ ID NO:17, and proteins comprising homologues of a protein having the amino acid sequence SEQ ID NO:14 or SEQ ID NO:17, wherein such a homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:14 or SEQ ID NO:17. Likewise, also preferred are proteins encoded by nucleic acid molecules  
10 comprising nucleic acid sequence SEQ ID NO:13 and/or SEQ ID NO:16, or by homologues thereof.

Additional preferred flea LGIC proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:20, SEQ ID NO:23 or SEQ ID NO:1862, and proteins comprising homologues of a protein having the amino acid sequence SEQ  
15 ID NO:20, SEQ ID NO:23 or SEQ ID NO:1862, wherein such a homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:20, SEQ ID NO:23 or SEQ ID NO:1862. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:19, SEQ ID NO:22, SEQ ID NO:1859, SEQ ID NO:1861 and/or SEQ ID NO:1864 or  
20 by homologues thereof.

Additional preferred flea ANON proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:26 or SEQ ID NO:29, and proteins

comprising homologues of a protein having the amino acid sequence SEQ ID NO:26 or SEQ ID NO:29, wherein such a homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:26 or SEQ ID NO:29. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:25 and/or SEQ ID NO:28, or by homologues thereof.

Additional preferred flea MALV proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:32 or SEQ ID NO:35, and proteins comprising homologues of a protein having the amino acid sequence SEQ ID NO:32 or SEQ ID NO:35, wherein such a homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:32 or SEQ ID NO:35. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:31 and/or SEQ ID NO:34, or by homologues thereof.

Additional preferred flea OS-D proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:38 or SEQ ID NO:41, and proteins comprising homologues of a protein having the amino acid sequence SEQ ID NO:38 or SEQ ID NO:41, wherein such a homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:38 or SEQ ID NO:41. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:37 and/or SEQ ID NO:40, or by homologues thereof.

Additional preferred flea NMDA proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:44 or SEQ ID NO:47, and proteins comprising homologues of a protein having the amino acid sequence SEQ ID NO:44 or SEQ ID NO:47, wherein such a homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:44 or SEQ ID NO:47. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:43 and/or SEQ ID NO:46, or by homologues thereof.

Additional preferred flea CLBP proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:154, SEQ ID NO:157, SEQ ID NO:160, SEQ ID NO:163, SEQ ID NO:166 or SEQ ID NO:169, and proteins comprising homologues of a protein having the amino acid sequence SEQ ID NO:154, SEQ ID NO:157, SEQ ID NO:160, SEQ ID NO:163, SEQ ID NO:166 or SEQ ID NO:169, wherein such a homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:154, SEQ ID NO:157, SEQ ID NO:160, SEQ ID NO:163, SEQ ID NO:166 or SEQ ID NO:169. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:153, SEQ ID NO:156, SEQ ID NO:159, SEQ ID NO:162, SEQ ID NO:165 and/or SEQ ID NO:168, or by homologues thereof.

Additional preferred flea NAH proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:1868, and proteins comprising homologues of a protein having the amino acid sequence SEQ ID NO:1868, wherein such a

homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:1868. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:1867 and/or SEQ ID NO:1870, or by homologues thereof.

5 Additional preferred flea CLIC proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:1873, and proteins comprising homologues of a protein having the amino acid sequence SEQ ID NO:1873, wherein such a homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:1873. Likewise, also preferred are  
10 proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:1872 and/or SEQ ID NO:1875, or by homologues thereof.

Additional preferred flea PL2 proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:1883, and proteins comprising homologues of a protein having the amino acid sequence SEQ ID NO:1883, wherein such a  
15 homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:1883. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:1877, SEQ ID NO:1878, SEQ ID NO:1880, SEQ ID NO:1882 and/or SEQ ID NO:1885, or by homologues thereof.

20 Additional preferred flea PL3 proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:1888, and proteins comprising homologues of a protein having the amino acid sequence SEQ ID NO:1888, wherein such a

homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:1888. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:1887 and/or SEQ ID NO:1890, or by homologues thereof.

5 Additional preferred flea PL4 proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:1897, and proteins comprising homologues of a protein having the amino acid sequence SEQ ID NO:1897, wherein such a homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:1897. Likewise, also preferred are  
10 proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:1892, SEQ ID NO:1894, SEQ ID NO:1896 and/or SEQ ID NO:1899, or by homologues thereof.

Additional preferred flea SVP proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:1902, and proteins comprising homologues  
15 of a protein having the amino acid sequence SEQ ID NO:1902, wherein such a homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:1902. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:1901 and/or SEQ ID NO:1904, or by homologues thereof.

20 Additional preferred flea VGCC proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:1915, and proteins comprising homologues of a protein having the amino acid sequence SEQ ID NO:1915, wherein such a

homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:1915. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:1906, SEQ ID NO:1908, SEQ ID NO:1910, SEQ ID NO:1912, SEQ ID NO:1914  
5 and/or SEQ ID NO:1917, or by homologues thereof.

Additional preferred flea AUP proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:1920, and proteins comprising homologues of a protein having the amino acid sequence SEQ ID NO:1920, wherein such a homologue comprises at least one epitope that elicits an immune response against a  
10 protein having an amino acid sequence SEQ ID NO:1920. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:1919 and/or SEQ ID NO:1922, or by homologues thereof.

Additional preferred flea 7B2 proteins of the present invention include proteins having the amino acid sequence SEQ ID NO:1925 or SEQ ID NO:1930, and proteins  
15 comprising homologues of a protein having the amino acid sequence SEQ ID NO:1925 or SEQ ID NO:1930, wherein such a homologue comprises at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:1925 or SEQ ID NO:1930. Likewise, also preferred are proteins encoded by nucleic acid molecules comprising nucleic acid sequence SEQ ID NO:1924, SEQ ID NO:1927 and/or  
20 SEQ ID NO:1929, or by homologues thereof.

Additional preferred flea HMT and/or HNC proteins of the present invention include proteins having an amino acid sequence encoded by a nucleic acid sequence of



Table I, Table II, Table III and/or Table IV, and proteins comprising homologues of a protein encoded by a nucleic acid sequence of Table I, Table II, Table III and/or Table IV, wherein such a homologue comprises at least one epitope that elicits an immune response against a protein encoded by a nucleic acid sequence of Table I, Table II, Table  
5 III and/or Table IV.

A preferred isolated protein of the present invention is a protein encoded by at least one of the following nucleic acid molecules: nCfALN<sub>2057</sub>, nCfALN<sub>1152</sub>, nCfCBP<sub>1128</sub>, nCfCBP<sub>816</sub>, nCfNKAB<sub>1714</sub>, nCfNKAB<sub>978</sub>, nCfLGIC<sub>2240</sub>, nCfLGIC<sub>1707</sub>, nCfANON<sub>1429</sub>, nCfANON<sub>1194</sub>, nCfMALV<sub>765</sub>, nCfMALV<sub>762</sub>, nCfOSD<sub>604</sub>, nCfOSD<sub>405</sub>, nCfNMDA<sub>1227</sub>,  
10 nCfNMDA<sub>738</sub>, nCfCLBP1A<sub>633</sub>, nCfCLBP1A<sub>441</sub>, nCfCLBP2A<sub>631</sub>, nCfCLBP2A<sub>441</sub>, nCfLGIC<sub>2739</sub>, nCfLGIC<sub>2016</sub>, nCfNAH<sub>2080</sub>, nCfNAH<sub>1824</sub>, nCfCLIC<sub>2283</sub>, nCfCLIC<sub>786</sub>, nCfPL2<sub>1291</sub>, nCfPL2<sub>1173</sub>, nCfPL3<sub>406</sub>, nCfPL3<sub>243</sub>, nCfPL4<sub>974</sub>, nCfPL4<sub>1043</sub>, nCfPL4<sub>1062</sub>, nCfPL4<sub>855</sub>, nCfSVP<sub>1875</sub>, nCfSVP<sub>1590</sub>, nCfVGCC<sub>381</sub>, nCfVGCC<sub>2191</sub>, nCfVGCC<sub>1968</sub>, nCfVGCC<sub>673</sub>, nCfVGCC<sub>3126</sub>, nCfVGCC<sub>2553</sub>, nCfAUP<sub>1181</sub>, nCfAUP<sub>306</sub>, nCf7B2<sub>2161</sub>,  
15 nCf7B2<sub>801</sub>, nCf7B2<sub>741</sub> or allelic variants of any of these nucleic acid molecules. Another preferred isolated protein is encoded by a nucleic acid molecule having nucleic acid sequence SEQ ID NO:1, SEQ ID NO:4, SEQ ID NO:7, SEQ ID NO:10, SEQ ID NO:13, SEQ ID NO:16, SEQ ID NO:19, SEQ ID NO:22, SEQ ID NO:25, SEQ ID NO:28, SEQ ID NO:31, SEQ ID NO:34, SEQ ID NO:37, SEQ ID NO:40, SEQ ID NO:43, SEQ ID  
20 NO:46, SEQ ID NO:153, SEQ ID NO:156, SEQ ID NO:159, SEQ ID NO:162, SEQ ID NO:165, SEQ ID NO:168, SEQ ID NO:1859, SEQ ID NO:1861, SEQ ID NO:1864, SEQ ID NO:1867, SEQ ID NO:1870, SEQ ID NO:1872, SEQ ID NO:1875, SEQ ID NO:1877,

SEQ ID NO:1878, SEQ ID NO:1881, SEQ ID NO:1882, SEQ ID NO:1885, SEQ ID  
 NO:1887, SEQ ID NO:1890, SEQ ID NO:1892, SEQ ID NO:1894, SEQ ID NO:1896,  
 SEQ ID NO:1899, SEQ ID NO:1901, SEQ ID NO:1904, SEQ ID NO:1906, SEQ ID  
 NO:1908, SEQ ID NO:1910, SEQ ID NO:1912, SEQ ID NO:1914, SEQ ID NO:1917,  
 5 SEQ ID NO:1919, SEQ ID NO:1922, SEQ ID NO:1924, SEQ ID NO:1927, and/or SEQ  
 ID NO:1929; or a protein encoded by an allelic variant of any of these listed nucleic acid  
 molecules.

Preferred proteins of the present invention include proteins that are at least about  
 70%, preferably at least about 80%, more preferably at least about 85%, even more  
 10 preferably at least about 90%, even more preferably at least about 95%, and even more  
 preferably about 100% identical to PCfALN<sub>384</sub>, PCfCBP<sub>272</sub>, PCfNKAB<sub>326</sub>, PCfLGIC<sub>569</sub>,  
 PCfANON<sub>398</sub>, PCfMALV<sub>254</sub>, PCfOSD<sub>135</sub>, PCfNMDA<sub>246</sub>, PCfCLBP1A<sub>147</sub> or  
 PCfCLBP2A<sub>147</sub>. Additionally preferred are proteins encoded by allelic variants of a  
 nucleic acid molecules encoding proteins PCfALN<sub>384</sub>, PCfCBP<sub>272</sub>, PCfNKAB<sub>326</sub>,  
 15 PCfLGIC<sub>569</sub>, PCfANON<sub>398</sub>, PCfMALV<sub>254</sub>, PCfOSD<sub>135</sub>, PCfNMDA<sub>246</sub>, PCfCLBP1A<sub>147</sub>,  
 PCfCLBP2A<sub>147</sub>, PCfLGIC<sub>672</sub>, PCfNAH<sub>608</sub>, PCfCLIC<sub>262</sub>, PCfPL2<sub>391</sub>, PCfPL3<sub>81</sub>, PCfPL4<sub>285</sub>,  
 PCfSVP<sub>530</sub>, PCfVGCC<sub>851</sub>, PCfAUP<sub>102</sub>, PCf7B2<sub>267</sub>, PCf7B2<sub>247</sub>. Also preferred are  
 fragments thereof having at least about 6 amino acid residues.

Other preferred HMT and HNC proteins of the present invention include proteins  
 20 having amino acid sequences that are at least about 70%, preferably at least about 80%,  
 more preferably at least about 85%, even more preferably at least about 90%, even more  
 preferably at least about 95%, and even more preferably about 100% identical to amino

acid sequence SEQ ID NO:2, SEQ ID NO:8, SEQ ID NO:14, SEQ ID NO:20, SEQ ID NO:26, SEQ ID NO:32, SEQ ID NO:38, SEQ ID NO:44, SEQ ID NO:154, SEQ ID NO:160, SEQ ID NO:163, SEQ ID NO:169, SEQ ID NO:1862, SEQ ID NO:1868, SEQ ID NO:1873, SEQ ID NO:1879, SEQ ID NO:1883, SEQ ID NO:1888, SEQ ID NO:1897, SEQ ID NO:1902, SEQ ID NO:1915, SEQ ID NO:1920, SEQ ID NO:1925, and/or SEQ ID NO:1930; and proteins encoded by allelic variants of nucleic acid molecules encoding HMT and HNC proteins having amino acid sequences SEQ ID NO:2, SEQ ID NO:8, SEQ ID NO:14, SEQ ID NO:20, SEQ ID NO:26, SEQ ID NO:32, SEQ ID NO:38, SEQ ID NO:44, SEQ ID NO:154, SEQ ID NO:160, SEQ ID NO:163, SEQ ID NO:169, SEQ ID NO:1862, SEQ ID NO:1868, SEQ ID NO:1873, SEQ ID NO:1879, SEQ ID NO:1883, SEQ ID NO:1888, SEQ ID NO:1897, SEQ ID NO:1902, SEQ ID NO:1915, SEQ ID NO:1920, SEQ ID NO:1925, and/or SEQ ID NO:1930. Also preferred are fragments thereof having at least about 6 amino acid residues.

In one embodiment of the present invention, *C. felis* HMT and HNC proteins comprise amino acid sequence SEQ ID NO:2, SEQ ID NO:8, SEQ ID NO:14, SEQ ID NO:20, SEQ ID NO:26, SEQ ID NO:32, SEQ ID NO:38, SEQ ID NO:44, SEQ ID NO:154, SEQ ID NO:160, SEQ ID NO:163, SEQ ID NO:169, SEQ ID NO:1862, SEQ ID NO:1868, SEQ ID NO:1873, SEQ ID NO:1879, SEQ ID NO:1883, SEQ ID NO:1888, SEQ ID NO:1897, SEQ ID NO:1902, SEQ ID NO:1915, SEQ ID NO:1920, SEQ ID NO:1925, and/or SEQ ID NO:1930 (including, but not limited to, the proteins consisting of amino acid sequence SEQ ID NO:2, SEQ ID NO:8, SEQ ID NO:14, SEQ ID NO:20, SEQ ID NO:26, SEQ ID NO:32, SEQ ID NO:38, SEQ ID NO:44, SEQ ID NO:154, SEQ

ID NO:160, SEQ ID NO:163, SEQ ID NO:169, SEQ ID NO:1862, SEQ ID NO:1868,  
 SEQ ID NO:1873, SEQ ID NO:1879, SEQ ID NO:1883, SEQ ID NO:1888, SEQ ID  
 NO:1897, SEQ ID NO:1902, SEQ ID NO:1915, SEQ ID NO:1920, SEQ ID NO:1925,  
 and/or SEQ ID NO:1930, fusion proteins and multivalent proteins), and proteins encoded  
 5 by allelic variants of nucleic acid molecules encoding proteins having amino acid  
 sequence SEQ ID NO:2, SEQ ID NO:8, SEQ ID NO:14, SEQ ID NO:20, SEQ ID NO:26,  
 SEQ ID NO:32, SEQ ID NO:38, SEQ ID NO:44, SEQ ID NO:154, SEQ ID NO:160,  
 SEQ ID NO:163, SEQ ID NO:169, SEQ ID NO:1862, SEQ ID NO:1868, SEQ ID  
 NO:1873, SEQ ID NO:1879, SEQ ID NO:1883, SEQ ID NO:1888, SEQ ID NO:1897,  
 10 SEQ ID NO:1902, SEQ ID NO:1915, SEQ ID NO:1920, SEQ ID NO:1925, and/or SEQ  
 ID NO:1930.

In one embodiment, a preferred flea HMT or HNC protein comprises an amino  
 acid sequence of at least about 35 amino acids, preferably at least about 50 amino acids,  
 more preferably at least about 100 amino acids, more preferably at least about 200 amino  
 15 acids, more preferably at least about 250 amino acids, more preferably at least about 300  
 amino acids, more preferably at least about 350 amino acids, more preferably at least  
 about 400 amino acids, more preferably at least about 450 amino acids, more preferably  
 at least about 500 amino acids, even more preferably at least about 550 amino acids, and  
 even more preferably at least about 575 amino acids. In another embodiment, preferred  
 20 flea HMT and HNC proteins comprise full-length proteins, i.e., proteins encoded by full-  
 length coding regions, or post-translationally modified proteins thereof, such as mature

proteins from which initiating methionine and/or signal sequences or “pro” sequences have been removed.

A fragment of an HMT and/or HNC protein of the present invention preferably comprises at least about 5 amino acids, more preferably at least about 10 amino acids, more preferably at least about 15 amino acids, more preferably at least about 20 amino acids, more preferably at least about 25 amino acids, more preferably at least about 30 amino acids, more preferably at least about 35 amino acids, more preferably at least about 40 amino acids, more preferably at least about 45 amino acids, more preferably at least about 50 amino acids, more preferably at least about 55 amino acids, more preferably at least about 60 amino acids, more preferably at least about 65 amino acids, more preferably at least about 70 amino acids, more preferably at least about 75 amino acids, more preferably at least about 80 amino acids, more preferably at least about 85 amino acids, more preferably at least about 90 amino acids, more preferably at least about 95 amino acids, and even more preferably at least about 100 amino acids in length.

Additional preferred HMT and HNC proteins of the present invention include proteins encoded by nucleic acid molecules comprising at least a portion of nCfALN<sub>2057</sub>, nCfALN<sub>1152</sub>, nCfCBP<sub>1128</sub>, nCfCBP<sub>816</sub>, nCfNKAB<sub>1714</sub>, nCfNKAB<sub>978</sub>, nCfLGIC<sub>2240</sub>, nCfLGIC<sub>1707</sub>, nCfANON<sub>1429</sub>, nCfANON<sub>1194</sub>, nCfMALV<sub>765</sub>, nCfMALV<sub>762</sub>, nCfOSD<sub>604</sub>, nCfOSD<sub>405</sub>, nCfNMDA<sub>1227</sub>, nCfNMDA<sub>738</sub>, nCfCLBP1A<sub>633</sub>, nCfCLBP1A<sub>441</sub>, nCfCLBP2A<sub>631</sub>, nCfCLBP2A<sub>441</sub>, nCfLGIC<sub>2739</sub>, nCfLGIC<sub>2016</sub>, nCfNAH<sub>2080</sub>, nCfNAH<sub>1824</sub>, nCfCLIC<sub>2283</sub>, nCfCLIC<sub>786</sub>, nCfPL2<sub>1291</sub>, nCfPL2<sub>1173</sub>, nCfPL3<sub>406</sub>, nCfPL3<sub>243</sub>, nCfPL4<sub>974</sub>, nCfPL4<sub>1043</sub>, nCfPL4<sub>1062</sub>, nCfPL4<sub>855</sub>, nCfSVP<sub>1875</sub>, nCfSVP<sub>1590</sub>, nCfVGCC<sub>381</sub>, nCfVGCC<sub>2191</sub>,

nCfVGCC<sub>1968</sub>, nCfVGCC<sub>673</sub>, nCfVGCC<sub>3126</sub>, nCfVGCC<sub>2553</sub>, nCfAUP<sub>1181</sub>, nCfAUP<sub>306</sub>, nCf7B2<sub>2161</sub>, nCf7B2<sub>801</sub>, nCf7B2<sub>741</sub> as well as HMT and HNC proteins encoded by allelic variants of such nucleic acid molecules. A portion of such HMT and HNC nucleic acid molecule is preferably at least 18 nucleotides in length.

5 Also preferred are HMT and HNC proteins encoded by nucleic acid molecules having nucleic acid sequences comprising at least a portion of SEQ ID NO:1, SEQ ID NO:4, SEQ ID NO:7, SEQ ID NO:10, SEQ ID NO:13, SEQ ID NO:16, SEQ ID NO:19, SEQ ID NO:22, SEQ ID NO:25, SEQ ID NO:28, SEQ ID NO:31, SEQ ID NO:34, SEQ ID NO:37, SEQ ID NO:40, SEQ ID NO:43, SEQ ID NO:46, SEQ ID NO:153, SEQ ID  
10 NO:156, SEQ ID NO:159, SEQ ID NO:162, SEQ ID NO:165, SEQ ID NO:168, SEQ ID NO:1859, SEQ ID NO:1861, SEQ ID NO:1864, SEQ ID NO:1867, SEQ ID NO:1870, SEQ ID NO:1872, SEQ ID NO:1875, SEQ ID NO:1877, SEQ ID NO:1878, SEQ ID NO:1881, SEQ ID NO:1882, SEQ ID NO:1885, SEQ ID NO:1887, SEQ ID NO:1890, SEQ ID NO:1892, SEQ ID NO:1894, SEQ ID NO:1896, SEQ ID NO:1899, SEQ ID  
15 NO:1901, SEQ ID NO:1904, SEQ ID NO:1906, SEQ ID NO:1908, SEQ ID NO:1910, SEQ ID NO:1912, SEQ ID NO:1914, SEQ ID NO:1917, SEQ ID NO:1919, SEQ ID NO:1922, SEQ ID NO:1924, SEQ ID NO:1927, and/or SEQ ID NO:1929, as well as allelic variants of these nucleic acid molecules. A portion of such HMT and HNC nucleic acid molecule is preferably at least 18 nucleotides in length.

20 In another embodiment, a preferred flea HMT and/or HNC protein of the present invention is encoded by a nucleic acid molecule comprising at least about 15 nucleotides, more preferably at least about 18 nucleotides, more preferably at least about 20

nucleotides, more preferably at least about 25 nucleotides, more preferably at least about 30 nucleotides, more preferably at least about 40 nucleotides, more preferably at least about 50 nucleotides, more preferably at least about 100 nucleotides, more preferably at least about 150 nucleotides, more preferably at least about 350 nucleotides, more preferably at least about 450 nucleotides, more preferably at least about 550 nucleotides, more preferably at least about 650 nucleotides, more preferably at least about 750 nucleotides, more preferably at least about 1000 nucleotides, more preferably at least about 1500 nucleotides, more preferably at least about 1750 nucleotides more preferably at least about 2000 nucleotides, and even more preferably at least about 2250 nucleotides in length. Within this embodiment is a HMT protein encoded by at least a portion of nCfALN<sub>2057</sub>, nCfALN<sub>1152</sub>, nCfCBP<sub>1128</sub>, nCfCBP<sub>816</sub>, nCfNKAB<sub>1714</sub>, nCfNKAB<sub>978</sub>, nCfLGIC<sub>2240</sub>, nCfLGIC<sub>1707</sub>, nCfANON<sub>1429</sub>, nCfANON<sub>1194</sub>, nCfMALV<sub>765</sub>, nCfMALV<sub>762</sub>, nCfOSD<sub>604</sub>, nCfOSD<sub>405</sub>, nCfNMDA<sub>1227</sub>, nCfNMDA<sub>738</sub>, nCfCLBP1A<sub>633</sub>, nCfCLBP1A<sub>441</sub>, nCfCLBP2A<sub>631</sub>, nCfCLBP2A<sub>441</sub>, nCfLGIC<sub>2739</sub>, nCfLGIC<sub>2016</sub>, nCfNAH<sub>2080</sub>, nCfNAH<sub>1824</sub>, nCfCLIC<sub>2283</sub>, nCfCLIC<sub>786</sub>, nCfPL2<sub>1291</sub>, nCfPL2<sub>1173</sub>, nCfPL3<sub>406</sub>, nCfPL3<sub>243</sub>, nCfPL4<sub>974</sub>, nCfPL4<sub>1043</sub>, nCfPL4<sub>1062</sub>, nCfPL4<sub>855</sub>, nCfSVP<sub>1875</sub>, nCfSVP<sub>1590</sub>, nCfVGCC<sub>381</sub>, nCfVGCC<sub>2191</sub>, nCfVGCC<sub>1968</sub>, nCfVGCC<sub>673</sub>, nCfVGCC<sub>3126</sub>, nCfVGCC<sub>2553</sub>, nCfAUP<sub>1181</sub>, nCfAUP<sub>306</sub>, nCf7B2<sub>2161</sub>, nCf7B2<sub>801</sub>, nCf7B2<sub>741</sub> or by an allelic variant of any of these nucleic acid molecules. In yet another embodiment, preferred flea HMT and HNC proteins of the present invention are encoded by nucleic acid molecules comprising apparently full-length HMT or HNC coding regions respectively, i.e., nucleic acid molecules encoding an apparently full-length HMT or HNC proteins.

Preferred flea HMT and HNC proteins of the present invention can be used to develop inhibitors that, when administered to an animal in an effective manner, are capable of protecting that animal from flea infestation. In accordance with the present invention, the ability of an inhibitor of the present invention to protect an animal from flea infestation refers to the ability of that protein to, for example, treat, ameliorate and/or prevent infestation caused by fleas. In particular, the phrase "to protect an animal from flea infestation" refers to reducing the potential for flea population expansion on and around the animal (i.e., reducing the flea burden). Preferably, the flea population size is decreased, optimally to an extent that the animal is no longer bothered by fleas. A host animal, as used herein, is an animal from which fleas can feed by attaching to and feeding through the skin of the animal. Fleas, and other ectoparasites, can live on a host animal for an extended period of time or can attach temporarily to an animal in order to feed. At any given time, a certain percentage of a flea population can be on a host animal whereas the remainder can be in the environment of the animal. Such an environment can include not only adult fleas, but also flea eggs and/or flea larvae. The environment can be of any size such that fleas in the environment are able to jump onto and off of a host animal. For example, the environment of an animal can include plants, such as crops, from which fleas infest an animal. As such, it is desirable not only to reduce the flea burden on an animal per se, but also to reduce the flea burden in the environment of the animal.

Suitable fleas to target include any flea that is essentially incapable of causing disease in an animal administered an inhibitor of the present invention. As such, fleas to target include any flea that produces a protein that can be targeted by an inhibitory compound that inhibits a flea HMT or HNC protein function, thereby resulting in the



decreased ability of the parasite to cause disease in an animal. Preferred fleas to target include fleas of the following genera: *Ctenocephalides*, *Cyopsyllus*, *Diamanus* (*Oropsylla*), *Echidnophaga*, *Nosopsyllus*, *Pulex*, *Tunga*, and *Xenopsylla*, with those of the species *Ctenocephalides canis*, *Ctenocephalides felis*, *Diamanus montanus*,

- 5 *Echidnophaga gallinacea*, *Nosopsyllus faciatus*, *Pulex irritans*, *Pulex simulans*, *Tunga penetrans* and *Xenopsylla cheopis* being more preferred, with *C. felis* being even more preferred. Such fleas are also preferred for the isolation of proteins or nucleic acid molecules of the present invention.

One embodiment of a flea HMT and/or HNC protein of the present invention is a  
 10 fusion protein that includes a flea HMT and/or HNC protein-containing domain attached to one or more fusion segments. Suitable fusion segments for use with the present invention include, but are not limited to, segments that can: enhance a protein's stability; act as an immunopotentiator to enhance an immune response against a flea HMT and/or HNC protein; and/or assist in purification of a flea HMT and/or HNC protein (e.g., by  
 15 affinity chromatography). A suitable fusion segment can be a domain of any size that has the desired function (e.g., imparts increased stability, imparts increased immunogenicity to a protein, and/or simplifies purification of a protein). Fusion segments can be joined to amino and/or carboxyl termini of the flea HMT-containing and/or HNC-containing domain of the protein and can be susceptible to cleavage in order to enable straight-  
 20 forward recovery of a flea HMT and/or HNC protein. Fusion proteins are preferably produced by culturing a recombinant cell transformed with a fusion nucleic acid molecule that encodes a protein including the fusion segment attached to either the carboxyl and/or

amino terminal end of an HMT-containing and/or HNC-containing domain. Preferred fusion segments include a metal binding domain (e.g., a poly-histidine segment); an immunoglobulin binding domain (e.g., Protein A; Protein G; T cell; B cell; Fc receptor or complement protein antibody-binding domains); a sugar binding domain (e.g., a maltose binding domain); and/or a "tag" domain (e.g., at least a portion of  $\beta$ -galactosidase, a strep tag peptide, a T7 tag peptide, a Flag<sup>TM</sup> peptide, or other domains that can be purified using compounds that bind to the domain, such as monoclonal antibodies). More preferred fusion segments include metal binding domains, such as a poly-histidine segment; a maltose binding domain; a strep tag peptide, such as that available from Biometra in Tampa, FL; and an S10 peptide.

The present invention also includes mimetopes of flea HMT and/or HNC proteins of the present invention. As used herein, a mimetope of a flea HMT and/or HNC protein of the present invention refers to any compound that is able to mimic the activity of such an HMT and/or HNC protein, often because the mimetope has a structure that mimics the particular HMT and/or HNC protein. Mimetopes can be, but are not limited to: peptides that have been modified to decrease their susceptibility to degradation such as all-D retro peptides; anti-idiotypic and/or catalytic antibodies, or fragments thereof; non-proteinaceous immunogenic portions of an isolated protein (e.g., carbohydrate structures); and synthetic or natural organic molecules, including nucleic acids. Such mimetopes can be designed using computer-generated structures of proteins of the present invention. Mimetopes can also be obtained by generating random samples of molecules, such as

oligonucleotides, peptides or other organic molecules, and screening such samples by affinity chromatography techniques using the corresponding binding partner.

Another embodiment of the present invention is an isolated nucleic acid molecule comprising a flea HMT and/or HNC nucleic acid molecule, i.e. a nucleic acid molecule that can be isolated from a HMT cDNA library, from a HNC cDNA library, or from both libraries. As used herein, HMT and HNC nucleic acid molecules has the same meaning as HMT and/or HNC nucleic acid molecule. The identifying characteristics of such nucleic acid molecules are heretofore described. A nucleic acid molecule of the present invention can include an isolated natural flea HMT and/or HNC gene or a homologue thereof, the latter of which is described in more detail below. A nucleic acid molecule of the present invention can include one or more regulatory regions, full-length or partial coding regions, or combinations thereof. The minimal size of a nucleic acid molecule of the present invention is a size sufficient to allow the formation of a stable hybrid (i.e., hybridization under stringent hybridization conditions) with the complementary sequence of another nucleic acid molecule. As such, the minimal size of a HMT and/or HNC nucleic acid molecule of the present invention is from about 12 to about 18 nucleotides in length. Suitable and preferred fleas from which to isolate nucleic acid molecules of the present invention are disclosed herein. Particularly preferred HMT and/or HNC nucleic acid molecules include *C. felis* HMT and/or HNC nucleic acid molecules.

In accordance with the present invention, an isolated nucleic acid molecule is a nucleic acid molecule that has been removed from its natural milieu (i.e., that has been subjected to human manipulation) and can include DNA, RNA, or derivatives of either

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DNA or RNA. As such, "isolated" does not reflect the extent to which the nucleic acid molecule has been purified. Isolated flea HMT and/or HNC nucleic acid molecules of the present invention, or homologues thereof, can be isolated from a natural source or produced using recombinant DNA technology (e.g., polymerase chain reaction (PCR) amplification or cloning) or chemical synthesis. Isolated flea HMT and/or HNC nucleic acid molecules, and homologues thereof, can include, for example, natural allelic variants and nucleic acid molecules modified by nucleotide insertions, deletions, substitutions, and/or inversions in a manner such that the modifications do not substantially interfere with the nucleic acid molecule's ability to encode a HMT and/or HNC protein of the present invention.

A flea HMT and/or HNC nucleic acid molecule homologue can be produced using a number of methods known to those skilled in the art, see, for example, Sambrook et al., *ibid.*, is incorporated by reference herein in its entirety. For example, nucleic acid molecules can be modified using a variety of techniques including, but not limited to, classic mutagenesis and recombinant DNA techniques such as site-directed mutagenesis, chemical treatment, restriction enzyme cleavage, ligation of nucleic acid fragments, PCR amplification, synthesis of oligonucleotide mixtures and ligation of mixture groups to "build" a mixture of nucleic acid molecules, and combinations thereof. Nucleic acid molecule homologues can be selected by hybridization with flea HMT and/or HNC nucleic acid molecules or by screening the function of a protein encoded by the nucleic acid molecule (e.g., ability to elicit an immune response against at least one epitope of a flea HMT or HNC protein or to effect HMT or HNC activity).

An isolated nucleic acid molecule of the present invention can include a nucleic acid sequence that encodes at least one flea HMT or HNC protein of the present invention, examples of such proteins being disclosed herein. Although the phrase "nucleic acid molecule" primarily refers to the physical nucleic acid molecule and the phrase "nucleic acid sequence" primarily refers to the sequence of nucleotides on the nucleic acid molecule, the two phrases can be used interchangeably, especially with respect to a nucleic acid molecule, or a nucleic acid sequence, being capable of encoding a flea HMT or HNC protein.

A preferred nucleic acid molecule of the present invention, when administered to an animal, is capable of protecting that animal from flea infestation. As will be disclosed in more detail below, such a nucleic acid molecule can be, or encode, an antisense RNA, a molecule capable of triple helix formation, a ribozyme, or other nucleic acid-based drug compound. In additional embodiments, a nucleic acid molecule of the present invention can encode a protective protein (e.g., an HMT or HNC protein of the present invention), the nucleic acid molecule being delivered to the animal, for example, by direct injection (i.e., as a genetic vaccine) or in a vehicle such as a recombinant virus vaccine or a recombinant cell vaccine.

In one embodiment of the present invention, a preferred flea HMT and/or HNC nucleic acid molecule includes an isolated nucleic acid molecule that hybridizes under conditions that preferably allow less than or equal to about 30% base pair mismatch, more preferably under conditions that allow less than or equal to about 25% base pair mismatch, more preferably under conditions that allow less than or equal to about 20%

base pair mismatch, more preferably under conditions that allow less than or equal to about 15% base pair mismatch, more preferably under conditions that allow less than or equal to about 10% base pair mismatch and even more preferably under conditions that allow less than or equal to about 5% base pair mismatch with a nucleic acid molecule

- 5 selected from the group consisting of SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:16, SEQ ID NO:18, SEQ ID NO:19, SEQ ID NO:21, SEQ ID NO:22, SEQ ID NO:24, SEQ ID NO:25, SEQ ID NO:27, SEQ ID NO:28, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:33, SEQ ID NO:34, SEQ ID NO:36, SEQ ID
- 10 NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45, SEQ ID NO:46, SEQ ID NO:48, SEQ ID NO:153, SEQ ID NO:155, SEQ ID NO:156, SEQ ID NO:158, SEQ ID NO:159, SEQ ID NO:161, SEQ ID NO:162, SEQ ID NO:164, SEQ ID NO:165, SEQ ID NO:167, SEQ ID NO:168, SEQ ID NO:170, SEQ ID NO:1859, SEQ ID NO:1860, SEQ ID NO:1861, SEQ ID NO:1863, SEQ ID NO:1864,
- 15 SEQ ID NO:1866, SEQ ID NO:1867, SEQ ID NO:1869, SEQ ID NO:1870, SEQ ID NO:1871, SEQ ID NO:1872, SEQ ID NO:1874, SEQ ID NO:1875, SEQ ID NO:1876, SEQ ID NO:1877, SEQ ID NO:1878, SEQ ID NO:1880, SEQ ID NO:1881, SEQ ID NO:1882, SEQ ID NO:1884, SEQ ID NO:1885, SEQ ID NO:1886, SEQ ID NO:1887, SEQ ID NO:1889, SEQ ID NO:1890, SEQ ID NO:1891, SEQ ID NO:1892, SEQ ID
- 20 NO:1893, SEQ ID NO:1894, SEQ ID NO:1895, SEQ ID NO:1896, SEQ ID NO:1898, SEQ ID NO:1899, SEQ ID NO:1900, SEQ ID NO:1901, SEQ ID NO:1903, SEQ ID NO:1904, SEQ ID NO:1905, SEQ ID NO:1906, SEQ ID NO:1907, SEQ ID NO:1908,

SEQ ID NO:1909, SEQ ID NO:1910, SEQ ID NO:1911, SEQ ID NO:1912, SEQ ID  
 NO:1913, SEQ ID NO:1914, SEQ ID NO:1916, SEQ ID NO:1917, SEQ ID NO:1918,  
 SEQ ID NO:1919, SEQ ID NO:1921, SEQ ID NO:1922, SEQ ID NO:1923, SEQ ID  
 NO:1924, SEQ ID NO:1926, SEQ ID NO:1927, SEQ ID NO:1928, SEQ ID NO:1929,  
 5 and/or SEQ ID NO:1931, a nucleic acid molecule of Table I, Table II, Table III or Table  
 IV and/or a nucleic acid molecule that is complementary to a nucleic acid molecule of  
 Table I, Table II, Table III or Table IV.

Another embodiment of the present invention includes a HMT and/or HNC  
 nucleic acid molecule, wherein said nucleic acid molecule hybridizes, in a solution  
 10 comprising 1X SSC and 0% formamide, at a temperature of about 47.5°C, to an isolated  
 nucleic acid molecule selected from the group consisting of SEQ ID NO:1, SEQ ID  
 NO:3, SEQ ID NO:4, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:9, SEQ ID NO:10, SEQ  
 ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:16, SEQ ID NO:18, SEQ ID  
 NO:19, SEQ ID NO:21, SEQ ID NO:22, SEQ ID NO:24, SEQ ID NO:25, SEQ ID  
 15 NO:27, SEQ ID NO:28, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:33, SEQ ID  
 NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID  
 NO:42, SEQ ID NO:43, SEQ ID NO:45, SEQ ID NO:46, SEQ ID NO:48, SEQ ID  
 NO:153, SEQ ID NO:155, SEQ ID NO:156, SEQ ID NO:158, SEQ ID NO:159, SEQ ID  
 NO:161, SEQ ID NO:162, SEQ ID NO:164, SEQ ID NO:165, SEQ ID NO:167, SEQ ID  
 20 NO:168, SEQ ID NO:170, SEQ ID NO:1859, SEQ ID NO:1860, SEQ ID NO:1861, SEQ  
 ID NO:1863, SEQ ID NO:1864, SEQ ID NO:1866, SEQ ID NO:1867, SEQ ID NO:1869,  
 SEQ ID NO:1870, SEQ ID NO:1871, SEQ ID NO:1872, SEQ ID NO:1874, SEQ ID

NO:1875, SEQ ID NO:1876, SEQ ID NO:1877, SEQ ID NO:1878, SEQ ID NO:1880,  
 SEQ ID NO:1881, SEQ ID NO:1882, SEQ ID NO:1884, SEQ ID NO:1885, SEQ ID  
 NO:1886, SEQ ID NO:1887, SEQ ID NO:1889, SEQ ID NO:1890, SEQ ID NO:1891,  
 SEQ ID NO:1892, SEQ ID NO:1893, SEQ ID NO:1894, SEQ ID NO:1895, SEQ ID  
 5 NO:1896, SEQ ID NO:1898, SEQ ID NO:1899, SEQ ID NO:1900, SEQ ID NO:1901,  
 SEQ ID NO:1903, SEQ ID NO:1904, SEQ ID NO:1905, SEQ ID NO:1906, SEQ ID  
 NO:1907, SEQ ID NO:1908, SEQ ID NO:1909, SEQ ID NO:1910, SEQ ID NO:1911,  
 SEQ ID NO:1912, SEQ ID NO:1913, SEQ ID NO:1914, SEQ ID NO:1916, SEQ ID  
 NO:1917, SEQ ID NO:1918, SEQ ID NO:1919, SEQ ID NO:1921, SEQ ID NO:1922,  
 10 SEQ ID NO:1923, SEQ ID NO:1924, SEQ ID NO:1926, SEQ ID NO:1927, SEQ ID  
 NO:1928, SEQ ID NO:1929, and/or SEQ ID NO:1931, a nucleic acid molecule of  
 Table I, Table II, Table III or Table IV and/or a nucleic acid molecule that is  
 complementary to a nucleic acid molecule of Table I, Table II, Table III or Table IV.  
 Additional preferred nucleic acid molecules of the present invention include  
 15 oligonucleotides of an isolated nucleic acid molecule, wherein said nucleic acid molecule  
 hybridizes, in a solution comprising 1X SSC and 0% formamide, at a temperature of  
 about 47.5°C, to an isolated nucleic acid molecule selected from the group consisting of  
 SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:6, SEQ ID NO:7, SEQ ID  
 NO:9, SEQ ID NO:10, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:16,  
 20 SEQ ID NO:18, SEQ ID NO:19, SEQ ID NO:21, SEQ ID NO:22, SEQ ID NO:24, SEQ  
 ID NO:25, SEQ ID NO:27, SEQ ID NO:28, SEQ ID NO:30, SEQ ID NO:31, SEQ ID  
 NO:33, SEQ ID NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID



NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45, SEQ ID NO:46, SEQ ID  
 NO:48, SEQ ID NO:153, SEQ ID NO:155, SEQ ID NO:156, SEQ ID NO:158, SEQ ID  
 NO:159, SEQ ID NO:161, SEQ ID NO:162, SEQ ID NO:164, SEQ ID NO:165, SEQ ID  
 NO:167, SEQ ID NO:168, SEQ ID NO:170, SEQ ID NO:1859, SEQ ID NO:1860, SEQ  
 5 ID NO:1861, SEQ ID NO:1863, SEQ ID NO:1864, SEQ ID NO:1866, SEQ ID NO:1867,  
 SEQ ID NO:1869, SEQ ID NO:1870, SEQ ID NO:1871, SEQ ID NO:1872, SEQ ID  
 NO:1874, SEQ ID NO:1875, SEQ ID NO:1876, SEQ ID NO:1877, SEQ ID NO:1878,  
 SEQ ID NO:1880, SEQ ID NO:1881, SEQ ID NO:1882, SEQ ID NO:1884, SEQ ID  
 NO:1885, SEQ ID NO:1886, SEQ ID NO:1887, SEQ ID NO:1889, SEQ ID NO:1890,  
 10 SEQ ID NO:1891, SEQ ID NO:1892, SEQ ID NO:1893, SEQ ID NO:1894, SEQ ID  
 NO:1895, SEQ ID NO:1896, SEQ ID NO:1898, SEQ ID NO:1899, SEQ ID NO:1900,  
 SEQ ID NO:1901, SEQ ID NO:1903, SEQ ID NO:1904, SEQ ID NO:1905, SEQ ID  
 NO:1906, SEQ ID NO:1907, SEQ ID NO:1908, SEQ ID NO:1909, SEQ ID NO:1910,  
 SEQ ID NO:1911, SEQ ID NO:1912, SEQ ID NO:1913, SEQ ID NO:1914, SEQ ID  
 15 NO:1916, SEQ ID NO:1917, SEQ ID NO:1918, SEQ ID NO:1919, SEQ ID NO:1921,  
 SEQ ID NO:1922, SEQ ID NO:1923, SEQ ID NO:1924, SEQ ID NO:1926, SEQ ID  
 NO:1927, SEQ ID NO:1928, SEQ ID NO:1929, and/or SEQ ID NO:1931, a nucleic acid  
 molecule of Table I, Table II, Table III or Table IV and/or a nucleic acid molecule that is  
 complementary to a nucleic acid molecule of Table I, Table II, Table III or Table IV,  
 20 wherein said oligonucleotide comprises at least about 18 nucleotides.

Additional preferred flea HMT and/or HNC nucleic acid molecules of the present  
 invention include nucleic acid molecules comprising a nucleic acid sequence that is

preferably at least about 70%, more preferably at least about 75%, more preferably at least about 80% more preferably at least about 85%, more preferably at least about 90%, and even more preferably at least about 95% identical to a nucleic acid sequence selected from the group consisting of SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:16, SEQ ID NO:18, SEQ ID NO:19, SEQ ID NO:21, SEQ ID NO:22, SEQ ID NO:24, SEQ ID NO:25, SEQ ID NO:27, SEQ ID NO:28, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:33, SEQ ID NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45, SEQ ID NO:46, SEQ ID NO:48, SEQ ID NO:153, SEQ ID NO:155, SEQ ID NO:156, SEQ ID NO:158, SEQ ID NO:159, SEQ ID NO:161, SEQ ID NO:162, SEQ ID NO:164, SEQ ID NO:165, SEQ ID NO:167, SEQ ID NO:168, SEQ ID NO:170, SEQ ID NO:1859, SEQ ID NO:1860, SEQ ID NO:1861, SEQ ID NO:1863, SEQ ID NO:1864, SEQ ID NO:1866, SEQ ID NO:1867, SEQ ID NO:1869, SEQ ID NO:1870, SEQ ID NO:1871, SEQ ID NO:1872, SEQ ID NO:1874, SEQ ID NO:1875, SEQ ID NO:1876, SEQ ID NO:1877, SEQ ID NO:1878, SEQ ID NO:1880, SEQ ID NO:1881, SEQ ID NO:1882, SEQ ID NO:1884, SEQ ID NO:1885, SEQ ID NO:1886, SEQ ID NO:1887, SEQ ID NO:1889, SEQ ID NO:1890, SEQ ID NO:1891, SEQ ID NO:1892, SEQ ID NO:1893, SEQ ID NO:1894, SEQ ID NO:1895, SEQ ID NO:1896, SEQ ID NO:1898, SEQ ID NO:1899, SEQ ID NO:1900, SEQ ID NO:1901, SEQ ID NO:1903, SEQ ID NO:1904, SEQ ID NO:1905, SEQ ID NO:1906, SEQ ID NO:1907, SEQ ID NO:1908, SEQ ID NO:1909, SEQ ID NO:1910, SEQ ID NO:1911, SEQ ID NO:1912, SEQ ID

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NO:1913, SEQ ID NO:1914, SEQ ID NO:1916, SEQ ID NO:1917, SEQ ID NO:1918, SEQ ID NO:1919, SEQ ID NO:1921, SEQ ID NO:1922, SEQ ID NO:1923, SEQ ID NO:1924, SEQ ID NO:1926, SEQ ID NO:1927, SEQ ID NO:1928, SEQ ID NO:1929, and/or SEQ ID NO:1931, a nucleic acid molecule of Table I, Table II, Table III or Table IV and/or a nucleic acid molecule that is complementary to a nucleic acid molecule of Table I, Table II, Table III or Table IV. Also preferred are oligonucleotides of any of such nucleic acid molecules. Percent identity may be determined using the GCG™ Wisconsin Package Version 9.0 sequence analysis software, using default parameters.

One embodiment of the present invention is a nucleic acid molecule comprising all or part of nucleic acid molecules nCfALN<sub>2057</sub>, nCfALN<sub>1152</sub>, nCfCBP<sub>1128</sub>, nCfCBP<sub>816</sub>, nCfNKAB<sub>1714</sub>, nCfNKAB<sub>978</sub>, nCfLGIC<sub>2240</sub>, nCfLGIC<sub>1707</sub>, nCfANON<sub>1429</sub>, nCfANON<sub>1194</sub>, nCfMALV<sub>765</sub>, nCfMALV<sub>762</sub>, nCfOSD<sub>604</sub>, nCfOSD<sub>405</sub>, nCfNMDA<sub>1227</sub>, nCfNMDA<sub>738</sub>, nCfCLBP1A<sub>633</sub>, nCfCLBP1A<sub>441</sub>, nCfCLBP2A<sub>631</sub>, nCfCLBP2A<sub>441</sub>, nCfLGIC<sub>2739</sub>, nCfLGIC<sub>2016</sub>, nCfNAH<sub>2080</sub>, nCfNAH<sub>1824</sub>, nCfCLIC<sub>2283</sub>, nCfCLIC<sub>786</sub>, nCfPL2<sub>1291</sub>, nCfPL2<sub>1173</sub>, nCfPL3<sub>406</sub>, nCfPL3<sub>243</sub>, nCfPL4<sub>974</sub>, nCfPL4<sub>1043</sub>, nCfPL4<sub>1062</sub>, nCfPL4<sub>855</sub>, nCfSVP<sub>1875</sub>, nCfSVP<sub>1590</sub>, nCfVGCC<sub>381</sub>, nCfVGCC<sub>2191</sub>, nCfVGCC<sub>1968</sub>, nCfVGCC<sub>673</sub>, nCfVGCC<sub>3126</sub>, nCfVGCC<sub>2553</sub>, nCfAUP<sub>1181</sub>, nCfAUP<sub>306</sub>, nCf7B2<sub>2161</sub>, nCf7B2<sub>801</sub>, nCf7B2<sub>741</sub> or allelic variants of these nucleic acid molecules. Another preferred nucleic acid molecule of the present invention includes at least a portion of nucleic acid sequence SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:16, SEQ ID NO:18, SEQ ID NO:19, SEQ ID NO:21, SEQ ID NO:22, SEQ ID NO:24, SEQ ID

NO:25, SEQ ID NO:27, SEQ ID NO:28, SEQ ID NO:30, SEQ ID NO:31, SEQ ID  
 NO:33, SEQ ID NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID  
 NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45, SEQ ID NO:46, SEQ ID  
 NO:48, SEQ ID NO:153, SEQ ID NO:155, SEQ ID NO:156, SEQ ID NO:158, SEQ ID  
 5 NO:159, SEQ ID NO:161, SEQ ID NO:162, SEQ ID NO:164, SEQ ID NO:165, SEQ ID  
 NO:167, SEQ ID NO:168, SEQ ID NO:170, SEQ ID NO:1859, SEQ ID NO:1860, SEQ  
 ID NO:1861, SEQ ID NO:1863, SEQ ID NO:1864, SEQ ID NO:1866, SEQ ID NO:1867,  
 SEQ ID NO:1869, SEQ ID NO:1870, SEQ ID NO:1871, SEQ ID NO:1872, SEQ ID  
 NO:1874, SEQ ID NO:1875, SEQ ID NO:1876, SEQ ID NO:1877, SEQ ID NO:1878,  
 10 SEQ ID NO:1880, SEQ ID NO:1881, SEQ ID NO:1882, SEQ ID NO:1884, SEQ ID  
 NO:1885, SEQ ID NO:1886, SEQ ID NO:1887, SEQ ID NO:1889, SEQ ID NO:1890,  
 SEQ ID NO:1891, SEQ ID NO:1892, SEQ ID NO:1893, SEQ ID NO:1894, SEQ ID  
 NO:1895, SEQ ID NO:1896, SEQ ID NO:1898, SEQ ID NO:1899, SEQ ID NO:1900,  
 SEQ ID NO:1901, SEQ ID NO:1903, SEQ ID NO:1904, SEQ ID NO:1905, SEQ ID  
 15 NO:1906, SEQ ID NO:1907, SEQ ID NO:1908, SEQ ID NO:1909, SEQ ID NO:1910,  
 SEQ ID NO:1911, SEQ ID NO:1912, SEQ ID NO:1913, SEQ ID NO:1914, SEQ ID  
 NO:1916, SEQ ID NO:1917, SEQ ID NO:1918, SEQ ID NO:1919, SEQ ID NO:1921,  
 SEQ ID NO:1922, SEQ ID NO:1923, SEQ ID NO:1924, SEQ ID NO:1926, SEQ ID  
 NO:1927, SEQ ID NO:1928, SEQ ID NO:1929, and/or SEQ ID NO:1931, and/or a  
 20 nucleic acid molecule of Table I, Table II, Table III or Table IV, as well as allelic variants  
 of nucleic acid molecules having these nucleic acid sequences and homologues of nucleic  
 acid molecules having these nucleic acid sequences; preferably such a homologue

encodes or is complementary to a nucleic acid molecule that encodes at least one epitope that elicits an immune response against a protein having an amino acid sequence SEQ ID NO:2, SEQ ID NO:8, SEQ ID NO:14, SEQ ID NO:20, SEQ ID NO:26, SEQ ID NO:32, SEQ ID NO:38, SEQ ID NO:44, SEQ ID NO:154, SEQ ID NO:160, SEQ ID NO:163, SEQ ID NO:169, SEQ ID NO:1862, SEQ ID NO:1868, SEQ ID NO:1873, SEQ ID NO:1879, SEQ ID NO:1883, SEQ ID NO:1888, SEQ ID NO:1897, SEQ ID NO:1902, SEQ ID NO:1915, SEQ ID NO:1920, SEQ ID NO:1925, and/or SEQ ID NO:1930. Such nucleic acid molecules can include nucleotides in addition to those included in the SEQ ID NOs, such as, but not limited to, a full-length gene, a full-length coding region, a nucleic acid molecule encoding a fusion protein, or a nucleic acid molecule encoding a multivalent protective compound.

In one embodiment, HMT and/or HNC nucleic acid molecule of the present invention encodes a protein that is at least about 70%, preferably at least about 75%, more preferably at least about 80%, even more preferably at least about 85%, even more preferably at least about 90%, even more preferably at least about 95%, even more preferably at least about 98%, and even more preferably at least about 100% identical to PCfALN<sub>384</sub>, PCfCBP<sub>272</sub>, PCfNKAB<sub>326</sub>, PCfLGIC<sub>569</sub>, PCfANON<sub>398</sub>, PCfMALV<sub>254</sub>, PCfOSD<sub>135</sub>, PCfNMDA<sub>246</sub>, PCfCLBP1A<sub>147</sub>, PCfCLBP2A<sub>147</sub>, PCfLGIC<sub>672</sub>, PCfNAH<sub>608</sub>, PCfCLIC<sub>262</sub>, PCfPL2<sub>391</sub>, PCfPL3<sub>81</sub>, PCfPL4<sub>285</sub>, PCfSVP<sub>530</sub>, PCfVGCC<sub>851</sub>, PCfAUP<sub>102</sub>, PCf7B2<sub>267</sub>, PCf7B2<sub>247</sub> and/or a protein encoded by a nucleic acid molecule having a sequence of Table I, Table II, Table III and/or Table IV.

In one embodiment, a HMT and/or HNC nucleic acid molecule of the present invention encodes a protein having an amino acid sequence that is at least about 70%, preferably at least about 75%, more preferably at least about 80%, even more preferably at least about 85%, even more preferably at least about 90%, even more preferably at least about 95%, even more preferably at least about 98%, and even more preferably at least about 100% identical to SEQ ID NO:2, SEQ ID NO:8, SEQ ID NO:14, SEQ ID NO:20, SEQ ID NO:26, SEQ ID NO:32, SEQ ID NO:38, SEQ ID NO:44, SEQ ID NO:154, SEQ ID NO:160, SEQ ID NO:163, SEQ ID NO:169, SEQ ID NO:1862, SEQ ID NO:1868, SEQ ID NO:1873, SEQ ID NO:1879, SEQ ID NO:1883, SEQ ID NO:1888, SEQ ID NO:1897, SEQ ID NO:1902, SEQ ID NO:1915, SEQ ID NO:1920, SEQ ID NO:1925, and/or SEQ ID NO:1930 and/or a protein encoded by a nucleic acid molecule having a sequence of Table I, Table II, Table III and/or Table IV. The present invention also includes a HMT and/or HNC nucleic acid molecule encoding a protein having at least a portion of SEQ ID NO:2, SEQ ID NO:8, SEQ ID NO:14, SEQ ID NO:20, SEQ ID NO:26, SEQ ID NO:32, SEQ ID NO:38, SEQ ID NO:44, SEQ ID NO:154, SEQ ID NO:160, SEQ ID NO:163, SEQ ID NO:169, SEQ ID NO:1862, SEQ ID NO:1868, SEQ ID NO:1873, SEQ ID NO:1879, SEQ ID NO:1883, SEQ ID NO:1888, SEQ ID NO:1897, SEQ ID NO:1902, SEQ ID NO:1915, SEQ ID NO:1920, SEQ ID NO:1925, and/or SEQ ID NO:1930 and/or a protein encoded by a nucleic acid molecule having a sequence of Table I, Table II, Table III and/or Table IV, as well as allelic variants of a nucleic acid molecule encoding a protein having these sequences, including nucleic acid molecules

that have been modified to accommodate codon usage properties of the cells in which such nucleic acid molecules are to be expressed.

In another embodiment, a preferred flea HMT and/or HNC nucleic acid molecule of the present invention comprises a nucleic acid molecule comprising at least about 15  
5 nucleotides, more preferably at least about 18 nucleotides, more preferably at least about 20 nucleotides, more preferably at least about 25 nucleotides, more preferably at least about 30 nucleotides, more preferably at least about 40 nucleotides, more preferably at least about 50 nucleotides, more preferably at least about 100 nucleotides, more preferably at least about 150 nucleotides, more preferably at least about 350 nucleotides,  
10 more preferably at least about 450 nucleotides, more preferably at least about 550 nucleotides, more preferably at least about 650 nucleotides, more preferably at least about 750 nucleotides, more preferably at least about 1000 nucleotides, more preferably at least about 1500 nucleotides, more preferably at least about 1750 nucleotides more preferably at least about 2000 nucleotides, and even more preferably at least about 2250 nucleotides  
15 in length.

In another embodiment, a preferred flea HMT and/or HNC nucleic acid molecule encodes a protein comprising at least about 5 amino acids, preferably at least about 6 amino acids, more preferably at least about 10 amino acids, more preferably at least about 15 amino acids, more preferably at least about 20 amino acids, more preferably at least about 25 amino acids, more preferably at least about 30 amino acids, more preferably at least about 40 amino acids; more preferably at least about 50 amino acids, more preferably at least about 100 amino acids, more preferably at least about 150 amino acids,

more preferably at least about 200 amino acids, more preferably at least about 300 amino acids, more preferably at least about 400 amino acids, more preferably at least about 500 amino acids, even more preferably at least about 560 amino acids in length.

In another embodiment, a preferred flea HMT and/or HNC nucleic acid molecule of the present invention comprises an apparently full-length HMT and/or HNC coding region, i.e., the preferred nucleic acid molecule encodes an apparently full-length HMT and/or HNC protein, or a post-translationally modified protein thereof. In one embodiment, a preferred HMT and/or HNC nucleic acid molecule of the present invention encodes a mature protein.

In another embodiment, a preferred flea HMT and/or HNC nucleic acid molecule of the present invention comprises a nucleic acid molecule comprising SEQ ID NO:1, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:6, SEQ ID NO:7, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:12, SEQ ID NO:13, SEQ ID NO:15, SEQ ID NO:16, SEQ ID NO:18, SEQ ID NO:19, SEQ ID NO:21, SEQ ID NO:22, SEQ ID NO:24, SEQ ID NO:25, SEQ ID NO:27, SEQ ID NO:28, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:33, SEQ ID NO:34, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:45, SEQ ID NO:46, SEQ ID NO:48, SEQ ID NO:153, SEQ ID NO:155, SEQ ID NO:156, SEQ ID NO:158, SEQ ID NO:159, SEQ ID NO:161, SEQ ID NO:162, SEQ ID NO:164, SEQ ID NO:165, SEQ ID NO:167, SEQ ID NO:168, SEQ ID NO:170, SEQ ID NO:1859, SEQ ID NO:1860, SEQ ID NO:1861, SEQ ID NO:1863, SEQ ID NO:1864, SEQ ID NO:1866, SEQ ID NO:1867, SEQ ID NO:1869, SEQ ID NO:1870, SEQ ID NO:1871, SEQ ID NO:1872, SEQ ID



NO:1874, SEQ ID NO:1875, SEQ ID NO:1876, SEQ ID NO:1877, SEQ ID NO:1878,  
 SEQ ID NO:1880, SEQ ID NO:1881, SEQ ID NO:1882, SEQ ID NO:1884, SEQ ID  
 NO:1885, SEQ ID NO:1886, SEQ ID NO:1887, SEQ ID NO:1889, SEQ ID NO:1890,  
 SEQ ID NO:1891, SEQ ID NO:1892, SEQ ID NO:1893, SEQ ID NO:1894, SEQ ID  
 5 NO:1895, SEQ ID NO:1896, SEQ ID NO:1898, SEQ ID NO:1899, SEQ ID NO:1900,  
 SEQ ID NO:1901, SEQ ID NO:1903, SEQ ID NO:1904, SEQ ID NO:1905, SEQ ID  
 NO:1906, SEQ ID NO:1907, SEQ ID NO:1908, SEQ ID NO:1909, SEQ ID NO:1910,  
 SEQ ID NO:1911, SEQ ID NO:1912, SEQ ID NO:1913, SEQ ID NO:1914, SEQ ID  
 NO:1916, SEQ ID NO:1917, SEQ ID NO:1918, SEQ ID NO:1919, SEQ ID NO:1921,  
 10 SEQ ID NO:1922, SEQ ID NO:1923, SEQ ID NO:1924, SEQ ID NO:1926, SEQ ID  
 NO:1927, SEQ ID NO:1928, SEQ ID NO:1929, and/or SEQ ID NO:1931.

Knowing the nucleic acid sequences of certain flea HMT and/or HNC nucleic acid  
 molecules of the present invention allows one skilled in the art to, for example, (a) make  
 copies of those nucleic acid molecules, (b) obtain nucleic acid molecules including at  
 15 least a portion of such nucleic acid molecules (e.g., nucleic acid molecules including full-  
 length genes, full-length coding regions, regulatory control sequences, truncated coding  
 regions), and (c) obtain other flea HMT and/or HNC nucleic acid molecules. Such  
 nucleic acid molecules can be obtained in a variety of ways including screening  
 appropriate expression libraries with antibodies of the present invention; traditional  
 20 cloning techniques using oligonucleotide probes of the present invention to screen  
 appropriate libraries; and PCR amplification of appropriate libraries or DNA using  
 oligonucleotide primers of the present invention. Preferred libraries to screen or from

which to amplify nucleic acid molecules include flea 1<sup>st</sup> instar larvae; 3<sup>rd</sup> instar larvae, wandering larvae, prepupal larvae, pupae and whole adult flea cDNA libraries as well as genomic DNA libraries. Similarly, preferred DNA sources to screen or from which to amplify nucleic acid molecules include flea prepupal cDNA, adult cDNA and genomic DNA. Techniques to clone and amplify genes are disclosed, for example, in Sambrook et al., *ibid.*

The present invention also includes nucleic acid molecules that are oligonucleotides capable of hybridizing, under stringent hybridization conditions, with complementary regions of other, preferably longer, nucleic acid molecules of the present invention such as those comprising *C. felis* HMT and/or HNC nucleic acid molecules or other flea HMT and/or HNC nucleic acid molecules. Oligonucleotides of the present invention can be RNA, DNA, or derivatives of either. The minimum size of such oligonucleotides is the size required for formation of a stable hybrid between an oligonucleotide and a complementary sequence on a nucleic acid molecule of the present invention. A preferred oligonucleotide of the present invention has a maximum size of preferably about 100 to 200 nucleotides. The present invention includes oligonucleotides that can be used as, for example, probes to identify nucleic acid molecules, primers to produce nucleic acid molecules, or therapeutic reagents to inhibit flea HMT and/or HNC protein production or activity (e.g., as antisense-, triplex formation-, ribozyme- and/or RNA drug-based reagents). The present invention also includes the use of such oligonucleotides to protect animals from disease using one or more of such technologies.

Appropriate oligonucleotide-containing therapeutic compositions can be administered to an animal using techniques known to those skilled in the art.

One embodiment of the present invention includes a recombinant vector, which includes at least one isolated nucleic acid molecule of the present invention, inserted into  
5 any vector capable of delivering the nucleic acid molecule into a host cell. Such a vector contains heterologous nucleic acid sequences, that is nucleic acid sequences that are not naturally found adjacent to nucleic acid molecules of the present invention and that preferably are derived from a species other than the species from which the nucleic acid molecule(s) are derived. The vector can be either RNA or DNA, either prokaryotic or  
10 eukaryotic, and typically is a virus or a plasmid. Recombinant vectors can be used in the cloning, sequencing, and/or otherwise manipulating of flea HMT and/or HNC nucleic acid molecules of the present invention.

One type of recombinant vector, referred to herein as a recombinant molecule, comprises a nucleic acid molecule of the present invention operatively linked to an  
15 expression vector. The phrase operatively linked refers to insertion of a nucleic acid molecule into an expression vector in a manner such that the molecule is able to be expressed when transformed into a host cell. As used herein, an expression vector is a DNA or RNA vector that is capable of transforming a host cell and of effecting expression of a specified nucleic acid molecule. Preferably, the expression vector is also  
20 capable of replicating within the host cell. Expression vectors can be either prokaryotic or eukaryotic, and are typically viruses or plasmids. Expression vectors of the present invention include any vectors that function (i.e., direct gene expression) in recombinant

cells of the present invention, including in bacterial, fungal, parasite, insect, other animal, and plant cells. Preferred expression vectors of the present invention can direct gene expression in bacterial, yeast, insect and mammalian cells, and more preferably in the cell types disclosed herein.

5           In particular, expression vectors of the present invention contain regulatory sequences such as transcription control sequences, translation control sequences, origins of replication, and other regulatory sequences that are compatible with the recombinant cell and that control the expression of nucleic acid molecules of the present invention. In particular, recombinant molecules of the present invention include transcription control  
10 sequences. Transcription control sequences are sequences that control the initiation, elongation, and termination of transcription. Particularly important transcription control sequences are those which control transcription initiation, such as promoter, enhancer, operator and repressor sequences. Suitable transcription control sequences include any transcription control sequence that can function in at least one of the recombinant cells of  
15 the present invention. A variety of such transcription control sequences are known to those skilled in the art. Preferred transcription control sequences include those that function in bacterial, yeast, or insect and mammalian cells, such as, but not limited to, *tac*, *lac*, *trp*, *trc*, oxy-pro, omp/lpp, *rrnB*, bacteriophage lambda (such as lambda  $p_L$  and lambda  $p_R$  and fusions that include such promoters), bacteriophage T7, T7*lac*,  
20 bacteriophage T3, bacteriophage SP6, bacteriophage SP01, metallothionein, alpha-mating factor, *Pichia* alcohol oxidase, alphavirus subgenomic promoter, antibiotic resistance gene, baculovirus, *Heliothis zea* insect virus, vaccinia virus, herpesvirus, raccoon

poxvirus, other poxvirus, adenovirus, cytomegalovirus (such as immediate early promoter), simian virus 40, retrovirus, actin, retroviral long terminal repeat, Rous sarcoma virus, heat shock, phosphate and nitrate transcription control sequences as well as other sequences capable of controlling gene expression in prokaryotic or eukaryotic

5 cells. Additional suitable transcription control sequences include tissue-specific promoters and enhancers as well as lymphokine-inducible promoters (e.g., promoters inducible by interferons or interleukins). Transcription control sequences of the present invention can also include naturally occurring transcription control sequences naturally associated with fleas, such as *C. felis* transcription control sequences.

10 Suitable and preferred nucleic acid molecules to include in recombinant vectors of the present invention are as disclosed herein. Preferred nucleic acid molecules to include in recombinant vectors, and particularly in recombinant molecules, include nucleic acid molecules having a sequence of Table I, Table II, Table III and/or Table IV. Particularly preferred nucleic acid molecules to include in recombinant vectors, and particularly in

15 recombinant molecules, include nCfALN<sub>2057</sub>, nCfALN<sub>1152</sub>, nCfCBP<sub>1128</sub>, nCfCBP<sub>816</sub>, nCfNKAB<sub>1714</sub>, nCfNKAB<sub>978</sub>, nCfLGIC<sub>2240</sub>, nCfLGIC<sub>1707</sub>, nCfANON<sub>1429</sub>, nCfANON<sub>1194</sub>, nCfMALV<sub>765</sub>, nCfMALV<sub>762</sub>, nCfOSD<sub>604</sub>, nCfOSD<sub>405</sub>, nCfNMDA<sub>1227</sub>, nCfNMDA<sub>738</sub>, nCfCLBP1A<sub>633</sub>, nCfCLBP1A<sub>441</sub>, nCfCLBP2A<sub>631</sub>, nCfCLBP2A<sub>441</sub>, nCfLGIC<sub>2739</sub>, nCfLGIC<sub>2016</sub>, nCfNAH<sub>2080</sub>, nCfNAH<sub>1824</sub>, nCfCLIC<sub>2283</sub>, nCfCLIC<sub>786</sub>, nCfPL2<sub>1291</sub>, nCfPL2<sub>1173</sub>, nCfPL3<sub>406</sub>, nCfPL3<sub>243</sub>, nCfPL4<sub>974</sub>, nCfPL4<sub>1043</sub>, nCfPL4<sub>1062</sub>, nCfPL4<sub>855</sub>, nCfSVP<sub>1875</sub>, nCfSVP<sub>1590</sub>, nCfVGCC<sub>381</sub>, nCfVGCC<sub>2191</sub>, nCfVGCC<sub>1968</sub>, nCfVGCC<sub>673</sub>, nCfVGCC<sub>3126</sub>, nCfVGCC<sub>2553</sub>, nCfAUP<sub>1181</sub>, nCfAUP<sub>306</sub>, nCf7B2<sub>2161</sub>, nCf7B2<sub>801</sub>, nCf7B2<sub>741</sub>.

20

Recombinant molecules of the present invention may also (a) contain secretory signals (i.e., signal segment nucleic acid sequences) to enable an expressed protein of the present invention to be secreted from the cell that produces the protein and/or (b) contain fusion sequences which lead to the expression of nucleic acid molecules of the present invention as fusion proteins. Examples of suitable signal segments include any signal segment capable of directing the secretion of a protein of the present invention. Preferred signal segments include, but are not limited to, tissue plasminogen activator (t-PA), interferon, interleukin, growth hormone, histocompatibility and viral envelope glycoprotein signal segments. Suitable fusion segments encoded by fusion segment nucleic acids are disclosed herein. In addition, a nucleic acid molecule of the present invention can be joined to a fusion segment that directs the encoded protein to the proteosome, such as a ubiquitin fusion segment. Eukaryotic recombinant molecules may also include intervening and/or untranslated sequences surrounding and/or within the nucleic acid sequences of nucleic acid molecules of the present invention.

Another embodiment of the present invention includes a recombinant cell comprising a host cell transformed with one or more recombinant molecules of the present invention. Transformation of a nucleic acid molecule into a cell can be accomplished by any method by which a nucleic acid molecule can be inserted into the cell. Transformation techniques include, but are not limited to, transfection, electroporation, microinjection, lipofection, adsorption, and protoplast fusion. A recombinant cell may remain unicellular or may grow into a tissue, organ or a multicellular organism. It is to be noted that a cell line refers to any recombinant cell of

the present invention that is not a transgenic animal. Transformed nucleic acid molecules of the present invention can remain extrachromosomal or can integrate into one or more sites within a chromosome of the transformed (i.e., recombinant) cell in such a manner that their ability to be expressed is retained. Preferred nucleic acid molecules with which to transform a cell include *C. felis* HMT and HNC nucleic acid molecules disclosed herein. Preferred nucleic acid molecules with which to transform a cell include nucleic acid molecules having a sequence of Table I, Table II, Table III and/or Table IV. Particularly preferred nucleic acid molecules with which to transform a cell include nCfALN<sub>2057</sub>, nCfALN<sub>1152</sub>, nCfCBP<sub>1128</sub>, nCfCBP<sub>816</sub>, nCfNKAB<sub>1714</sub>, nCfNKAB<sub>978</sub>, nCfLGIC<sub>2240</sub>, nCfLGIC<sub>1707</sub>, nCfANON<sub>1429</sub>, nCfANON<sub>1194</sub>, nCfMALV<sub>765</sub>, nCfMALV<sub>762</sub>, nCfOSD<sub>604</sub>, nCfOSD<sub>405</sub>, nCfNMDA<sub>1227</sub>, nCfNMDA<sub>738</sub>, nCfCLBP1A<sub>633</sub>, nCfCLBP1A<sub>441</sub>, nCfCLBP2A<sub>631</sub>, nCfCLBP2A<sub>441</sub>, nCfLGIC<sub>2739</sub>, nCfLGIC<sub>2016</sub>, nCfNAH<sub>2080</sub>, nCfNAH<sub>1824</sub>, nCfCLIC<sub>2283</sub>, nCfCLIC<sub>786</sub>, nCfPL2<sub>1291</sub>, nCfPL2<sub>1173</sub>, nCfPL3<sub>406</sub>, nCfPL3<sub>243</sub>, nCfPL4<sub>974</sub>, nCfPL4<sub>1043</sub>, nCfPL4<sub>1062</sub>, nCfPL4<sub>855</sub>, nCfSVP<sub>1875</sub>, nCfSVP<sub>1590</sub>, nCfVGCC<sub>381</sub>, nCfVGCC<sub>2191</sub>, nCfVGCC<sub>1968</sub>, nCfVGCC<sub>673</sub>, nCfVGCC<sub>3126</sub>, nCfVGCC<sub>2553</sub>, nCfAUP<sub>1181</sub>, nCfAUP<sub>306</sub>, nCf7B2<sub>2161</sub>, nCf7B2<sub>801</sub>, or nCf7B2<sub>741</sub>.

Suitable host cells to transform include any cell that can be transformed with a nucleic acid molecule of the present invention. Host cells can be either untransformed cells or cells that are already transformed with at least one nucleic acid molecule (e.g., nucleic acid molecules encoding one or more proteins of the present invention and/or other proteins useful in the production of multivalent vaccines). Host cells of the present invention either can be endogenously (i.e., naturally) capable of producing flea HMT

and/or HNC proteins of the present invention or can be capable of producing such proteins after being transformed with at least one nucleic acid molecule of the present invention. Host cells of the present invention can be any cell capable of producing at least one protein of the present invention, and include bacterial, fungal (including yeast),

5 parasite (including helminth, protozoa and ectoparasite), other insect, other animal and plant cells. Preferred host cells include bacterial, mycobacterial, yeast, insect and mammalian cells. More preferred host cells include *Salmonella*, *Escherichia*, *Bacillus*, *Caulobacter*, *Listeria*, *Saccharomyces*, *Pichia*, *Spodoptera*, *Mycobacteria*, *Trichoplusia*, BHK (baby hamster kidney) cells, MDCK cells (Madin-Darby canine kidney cell line),

10 CRFK cells (Crandell feline kidney cell line), CV-1 cells (African monkey kidney cell line used, for example, to culture raccoon poxvirus), COS (e.g., COS-7) cells, and Vero cells. Particularly preferred host cells are *Escherichia coli*, including *E. coli* K-12 derivatives; *Salmonella typhi*; *Salmonella typhimurium*, including attenuated strains such as UK-1  $\chi$ 3987 and SR-11  $\chi$ 4072; *Caulobacter*; *Pichia*; *Spodoptera frugiperda*;

15 *Trichoplusia ni*; BHK cells; MDCK cells; CRFK cells; CV-1 cells; COS cells; Vero cells; and non-tumorigenic mouse myoblast G8 cells (e.g., ATCC CRL 1246). Additional appropriate mammalian cell hosts include other kidney cell lines, other fibroblast cell lines (e.g., human, murine or chicken embryo fibroblast cell lines), myeloma cell lines, Chinese hamster ovary cells, mouse NIH/3T3 cells, LMTK<sup>31</sup> cells and/or HeLa cells. In

20 one embodiment, the proteins may be expressed as heterologous proteins in myeloma cell lines employing immunoglobulin promoters.



A recombinant cell is preferably produced by transforming a host cell with one or more recombinant molecules, each comprising one or more nucleic acid molecules of the present invention operatively linked to an expression vector containing one or more transcription control sequences, examples of which are disclosed herein. The phrase  
5 operatively linked refers to insertion of a nucleic acid molecule into an expression vector in a manner such that the molecule is able to be expressed when transformed into a host cell.

A recombinant cell of the present invention includes any cell transformed with at least one of any nucleic acid molecule of the present invention. Suitable and preferred  
10 nucleic acid molecules as well as suitable and preferred recombinant molecules with which to transfer cells are disclosed herein.

Recombinant cells of the present invention can also be co-transformed with one or more recombinant molecules including flea HMT and/or HNC nucleic acid molecules encoding one or more proteins of the present invention and one or more other nucleic acid  
15 molecules encoding other protective compounds, as disclosed herein (e.g., to produce multivalent vaccines).

Recombinant DNA technologies can be used to improve expression of transformed nucleic acid molecules by manipulating, for example, the number of copies of the nucleic acid molecules within a host cell, the efficiency with which those nucleic  
20 acid molecules are transcribed, the efficiency with which the resultant transcripts are translated, and the efficiency of post-translational modifications. Recombinant techniques useful for increasing the expression of nucleic acid molecules of the present

invention include, but are not limited to, operatively linking nucleic acid molecules to high-copy number plasmids, integration of the nucleic acid molecules into one or more host cell chromosomes, addition of vector stability sequences to plasmids, substitutions or modifications of transcription control signals (e.g., promoters, operators, enhancers), substitutions or modifications of translational control signals (e.g., ribosome binding sites, Shine-Dalgarno sequences), modification of nucleic acid molecules of the present invention to correspond to the codon usage of the host cell, deletion of sequences that destabilize transcripts, and use of control signals that temporally separate recombinant cell growth from recombinant enzyme production during fermentation. The activity of an expressed recombinant protein of the present invention may be improved by fragmenting, modifying, or derivatizing nucleic acid molecules encoding such a protein.

Isolated flea HMT and/or HNC proteins of the present invention can be produced in a variety of ways, including production and recovery of natural proteins, production and recovery of recombinant proteins, and chemical synthesis of the proteins. In one embodiment, an isolated protein of the present invention is produced by culturing a cell capable of expressing the protein under conditions effective to produce the protein, and recovering the protein. A preferred cell to culture is a recombinant cell of the present invention. Effective culture conditions include, but are not limited to, effective media, bioreactor, temperature, pH and oxygen conditions that permit protein production. An effective, medium refers to any medium in which a cell is cultured to produce a flea HMT and/or HNC protein of the present invention. Such medium typically comprises an aqueous medium having assimilable carbon, nitrogen and phosphate sources, and

appropriate salts, minerals, metals and other nutrients, such as vitamins. Cells of the present invention can be cultured in conventional fermentation bioreactors, shake flasks, test tubes, microtiter dishes, and petri plates. Culturing can be carried out at a temperature, pH and oxygen content appropriate for a recombinant cell. Such culturing

5 conditions are within the expertise of one of ordinary skill in the art. Examples of suitable conditions are included in the Examples section.

Depending on the vector and host system used for production, resultant proteins of the present invention may either remain within the recombinant cell; be secreted into the fermentation medium; be secreted into a space between two cellular membranes, such as

10 the periplasmic space in *E. coli*; or be retained on the outer surface of a cell or viral membrane.

The phrase "recovering the protein", as well as similar phrases, refers to collecting the whole fermentation medium containing the protein and need not imply additional steps of separation or purification. Proteins of the present invention can be purified using

15 a variety of standard protein purification techniques, such as, but not limited to, affinity chromatography, ion exchange chromatography, filtration, electrophoresis, hydrophobic interaction chromatography, gel filtration chromatography, reverse phase chromatography, concanavalin A chromatography, chromatofocusing and differential solubilization. Proteins of the present invention are preferably retrieved in "substantially

20 pure" form. As used herein, "substantially pure" refers to a purity that allows for the effective use of the protein as a therapeutic composition or diagnostic. A therapeutic composition for animals, for example, should exhibit no substantial toxicity and

preferably should be capable of stimulating the production of antibodies in a treated animal.

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The present invention also includes isolated (i.e., removed from their natural milieu) antibodies that selectively bind to a flea HMT and/or HNC protein of the present invention or a mimetope thereof (e.g., anti-*C. felis* HMT or HNC antibodies). As used herein, the term "selectively binds to" an HMT and/or HNC protein refers to the ability of antibodies of the present invention to preferentially bind to specified proteins and mimetopes thereof of the present invention. Binding can be measured using a variety of methods standard in the art including enzyme immunoassays (e.g., ELISA), immunoblot assays, etc.; see, for example, Sambrook et al., *ibid.*, and Harlow, et al., 1988, *Antibodies, a Laboratory Manual*, Cold Spring Harbor Labs Press; Harlow et al., *ibid.*, is incorporated by reference herein in its entirety. An anti-HMT or anti-HNC antibody of the present invention preferably selectively binds to a flea HMT or HNC protein respectively in such a way as to inhibit the function of that protein.

Isolated antibodies of the present invention can include antibodies in serum, or antibodies that have been purified to varying degrees. Antibodies of the present invention can be polyclonal or monoclonal, or can be functional equivalents such as antibody fragments and genetically-engineered antibodies, including single chain antibodies or chimeric antibodies that can bind to one or more epitopes.

A preferred method to produce antibodies of the present invention includes (a) administering to an animal an effective amount of a protein, peptide or mimetope thereof of the present invention to produce the antibodies and (b) recovering the

antibodies. In another method, antibodies of the present invention are produced recombinantly using techniques as heretofore disclosed to produce HMT and/or HNC proteins of the present invention. Antibodies raised against defined proteins or mimetopes can be advantageous because such antibodies are not substantially

5 contaminated with antibodies against other substances that might otherwise cause interference in a diagnostic assay or side effects if used in a therapeutic composition.

Antibodies of the present invention have a variety of potential uses that are within the scope of the present invention. For example, such antibodies can be used (a) as therapeutic compounds to passively immunize an animal in order to protect the animal

10 from fleas susceptible to treatment by such antibodies and/or (b) as tools to screen expression libraries and/or to recover desired proteins of the present invention from a mixture of proteins and other contaminants. Furthermore, antibodies of the present invention can be used to target cytotoxic agents to fleas in order to directly kill such fleas. Targeting can be accomplished by conjugating (i.e., stably joining) such antibodies to the

15 cytotoxic agents using techniques known to those skilled in the art. Suitable cytotoxic agents are known to those skilled in the art.

One embodiment of the present invention is a therapeutic composition that, when administered to an animal susceptible to flea infestation, is capable of protecting that animal from flea infestation. Therapeutic compositions of the present invention include

20 at least one of the following protective molecules: an isolated flea HMT and/or HNC protein; a mimetope of an isolated flea HMT and/or HNC protein; an isolated flea HMT and/or HNC nucleic acid molecule; and/or a compound derived from said isolated flea

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HMT and/or HNC protein that inhibits HMT and/or HNC protein activity. A therapeutic composition of the present invention can further comprise a component selected from the group of an excipient, a carrier, and/or an adjuvant; these components are described further herein. As used herein, a protective molecule or protective compound refers to a compound that, when administered to an animal in an effective manner, is able to treat, ameliorate, and/or prevent flea infestation. Preferred fleas to target are heretofore disclosed. One example of a protective molecule is a vaccine, such as, but not limited to, a naked nucleic acid vaccine, a recombinant virus vaccine, a recombinant cell vaccine, and a recombinant protein vaccine. Another example of a protective molecule is a compound that inhibits HMT and/or HNC protein activity, such as an isolated antibody that selectively binds to a flea HMT and/or HNC protein, a substrate analog of a flea HMT and/or HNC protein, anti-sense-, triplex formation-, ribozyme-, and/or RNA drug-based compounds, or other inorganic or organic molecules that inhibit HMT and/or HNC protein activity. Inhibiting flea HMT and/or HNC protein activity can refer to the ability of a compound to reduce the activity of flea HMT and/or HNC proteins. Inhibiting flea HMT and/or HNC protein activity can also refer to the ability of a compound to reduce the amount of flea HMT and/or HNC protein in a flea.

Another embodiment of the present invention includes a method to reduce a flea infestation in an animal susceptible to flea infestation. Such a method includes the step of administering to the animal a therapeutic molecule comprising a protective compound selected from the group consisting of (a) an isolated flea HMT and/or HNC protein; (b) a mimotope of an isolated flea HMT and/or HNC protein; (c) an isolated flea HMT and/or

HNC nucleic acid molecule; and (d) a compound derived from an isolated flea HMT and/or HNC protein that inhibits HMT and/or HNC protein activity.

Therapeutic compositions of the present invention can be administered to any animal susceptible to flea infestation, preferably to mammals, and more preferably to dogs, cats, humans, ferrets, horses, cattle, sheep, and other pets, economic food animals, work animals and/or zoo animals. Preferred animals to protect against flea infestation include dogs, cats, humans, and ferrets, with dogs and cats being particularly preferred.

As used herein, the term derived, or the term derived from, refers to a peptide, antibody, mimetope, nucleic acid molecule, or other compound that was obtained from a flea HMT and/or HNC protein or nucleic acid molecule of the present invention. Methods to obtain derivatives from a HMT and/or HNC molecule of the present invention are known in the art, and as such include, but are not limited to molecular modeling of HMT and/or HNC proteins to determine active sites, i.e. sites that interact with other molecules, and predicting from these active sites smaller fragments and/or mimetopes that retain and/or mimic these active sites, thereby inhibiting HMT and/or HNC protein activity; screening of peptide or small chemical compound libraries against HMT and/or HNC proteins of the present invention; and screening of polyclonal or monoclonal antibodies to find antibodies that specifically bind HMT and/or HNC proteins of the present invention.

A HMT and/or HNC protein inhibitor of the present invention is identified by its ability to bind to, modify, or otherwise interact with, a flea HMT and/or HNC protein, thereby inhibiting the activity of HMT and/or HNC proteins. Suitable inhibitors of HMT

and/or HNC protein activity are compounds that inhibit HMT and/or HNC protein activity in at least one of a variety of ways: (a) by binding to or otherwise interacting with or otherwise modifying HMT and/or HNC protein sites; (b) by binding to or otherwise interacting with or otherwise modifying the HMT and/or HNC protein active site; (c) by binding to the HMT and/or HNC protein and thus reducing the availability of the HMT and/or HNC protein in solution; and (d) by interacting with other regions of the HMT and/or HNC protein to inhibit HMT and/or HNC protein activity, for example, by allosteric interaction.

Flea HMT and/or HNC protein inhibitors can be used directly as compounds in compositions of the present invention to treat animals as long as such compounds are not harmful to host animals being treated. Preferred HMT and/or HNC protein inhibitors of the present invention include, but are not limited to, flea HMT and/or HNC protein substrate analogs, and other molecules that bind to a flea HMT and/or HNC proteins (e.g., to an allosteric site) in such a manner that the activity of the flea HMT and/or HNC protein is inhibited. A HMT and/or HNC protein substrate analog refers to a compound that interacts with (e.g., binds to, associates with, modifies) the active site of a HMT and/or HNC protein. A preferred HMT and/or HNC protein substrate analog inhibits HMT and/or HNC protein activity. HMT and/or HNC protein substrate analogs can be of any inorganic or organic composition. HMT and/or HNC protein substrate analogs can be, but need not be, structurally similar to a HMT and/or HNC protein natural substrate as long as they can interact with the active site of that HMT and/or HNC protein. HMT and/or HNC protein substrate analogs can be designed using computer-generated



structures of HMT and/or HNC proteins of the present invention or computer structures of HMT and/or HNC protein's natural substrates. Preferred sites to model include one or more of the active sites of HMT and/or HNC protein. Substrate analogs can also be obtained by generating random samples of molecules, such as oligonucleotides, peptides, peptidomimetic compounds, or other inorganic or organic molecules, and screening such samples for their ability to interfere with interaction between HMT and/or HNC proteins and their substrates, e.g. by affinity chromatography techniques. A preferred HMT and/or HNC protein substrate analog is a HMT and/or HNC protein mimetic compound, i.e., a compound that is structurally and/or functionally similar to a natural substrate of a HMT and/or HNC protein of the present invention, particularly to the region of the substrate that interacts with the HMT and/or HNC protein active site, but that inhibits HMT and/or HNC protein activity upon interacting with the HMT and/or HNC protein active site.

The present invention also includes a therapeutic composition comprising at least one protective molecule of the present invention in combination with at least one additional compound protective against one or more infectious agents.

In one embodiment, a therapeutic composition of the present invention can be used to protect an animal from flea infestation by administering such composition to a flea in order to prevent infestation. Such administration to the flea and/or animal could be oral, or by application to the animal's body surface (e.g. topical spot-on, or spraying onto the animal), or by application to the environment (e.g., spraying). Examples of such compositions include, but are not limited to, transgenic vectors capable of producing at

least one therapeutic composition of the present invention. In another embodiment a flea can ingest therapeutic compositions, or products thereof, present on the surface of or in the blood of a host animal that has been administered a therapeutic composition of the present invention.

5 In accordance with the present invention, a host animal (i.e., an animal that is or is capable of being infested with fleas) is treated by administering to the animal a therapeutic composition of the present invention in such a manner that the composition itself (e.g., a HMT and/or HNC protein inhibitor, a HMT and/or HNC protein synthesis suppressor (i.e., a compound that decreases the production or half-life of a HMT and/or  
10 HNC protein in fleas), a HMT and/or HNC protein mimetope, or a anti-HMT and/or HNC antibody) or a product generated by the animal in response to administration of the composition (e.g., antibodies produced in response to administration of a flea HMT and/or HNC protein or nucleic acid molecule, or conversion of an inactive inhibitor "prodrug" to an active HMT and/or HNC protein inhibitor) ultimately enters the flea. A  
15 host animal is preferably treated in such a way that the compound or product thereof is present on the body surface of the animal or enters the blood stream of the animal. Fleas are then exposed to the composition or product when they feed from the animal. For example, flea HMT and/or HNC protein inhibitors administered to an animal are administered in such a way that the inhibitors enter the blood stream of the animal, where  
20 they can be taken up by feeding fleas.

The present invention also includes the ability to reduce larval flea infestation in that when fleas feed from a host animal that has been administered a therapeutic

composition of the present invention, at least a portion of compounds of the present invention, or products thereof, in the blood taken up by the fleas are excreted by the fleas in feces, which is subsequently ingested by flea larvae. In particular, it is of note that flea larvae obtain most, if not all, of their nutrition from flea feces.

5 In accordance with the present invention, reducing HMT and/or HNC protein activity in a flea can lead to a number of outcomes that reduce flea burden on treated animals and their surrounding environments. Such outcomes include, but are not limited to, (a) reducing the viability of fleas that feed from the treated animal, (b) reducing the fecundity of female fleas that feed from the treated animal, (c) reducing the reproductive  
10 capacity of male fleas that feed from the treated animal, (d) reducing the viability of eggs laid by female fleas that feed from the treated animal, (e) altering the blood feeding behavior of fleas that feed from the treated animal (e.g., fleas take up less volume per feeding or feed less frequently), (f) reducing the viability of flea larvae, for example due to the feeding of larvae from feces of fleas that feed from the treated animal, (g) altering  
15 the development of flea larvae (e.g., by decreasing feeding behavior, inhibiting growth, inhibiting (e.g., slowing or blocking) molting, and/or otherwise inhibiting maturation to adults), and/or (h) altering or decreasing the ability of fleas or flea larvae to digest a blood meal.

In order to protect an animal from flea infestation, a therapeutic composition of  
20 the present invention is administered to the animal in an effective manner such that the composition is capable of protecting that animal from flea infestation. Therapeutic compositions of the present invention can be administered to animals prior to infestation in order to prevent infestation (i.e., as a preventative vaccine) and/or can be administered

to animals after infestation. For example, proteins, mimetopes thereof, and antibodies thereof can be used as immunotherapeutic agents.

Therapeutic compositions of the present invention can be formulated in an excipient that the animal to be treated can tolerate. Examples of such excipients include

5 water, saline, Ringer's solution, dextrose solution, Hank's solution, and other aqueous physiologically balanced salt solutions. Nonaqueous vehicles, such as fixed oils, sesame oil, ethyl oleate, or triglycerides may also be used. Other useful formulations include suspensions containing viscosity enhancing agents, such as sodium

10 carboxymethylcellulose, sorbitol, or dextran. Excipients can also contain minor amounts of additives, such as substances that enhance isotonicity and chemical stability. Examples of buffers include phosphate buffer, bicarbonate buffer and Tris buffer, while examples of preservatives include thimerosal, or o-cresol, formalin and benzyl alcohol. Standard formulations can either be liquid injectables or solids which can be taken up in a suitable liquid as a suspension or solution for injection. Thus, in a non-liquid

15 formulation, the excipient can comprise dextrose, human serum albumin, preservatives, etc., to which sterile water or saline can be added prior to administration.

In one embodiment of the present invention, a therapeutic composition can include an adjuvant. Adjuvants are agents that are capable of enhancing the immune response of an animal to a specific antigen. Suitable adjuvants include, but are not

20 limited to, cytokines, chemokines, and compounds that induce the production of cytokines and chemokines (e.g., granulocyte macrophage colony stimulating factor (GM-CSF), Flt-3 ligand, granulocyte colony stimulating factor (G-CSF), macrophage colony

stimulating factor (M-CSF), colony stimulating factor (CSF), erythropoietin (EPO), interleukin 2 (IL-2), interleukin-3 (IL-3), interleukin 4 (IL-4), interleukin 5 (IL-5), interleukin 6 (IL-6), interleukin 7 (IL-7), interleukin 8 (IL-8), interleukin 10 (IL-10), interleukin 12 (IL-12), interferon gamma, interferon gamma inducing factor I (IGIF),

5 transforming growth factor beta, RANTES (regulated upon activation, normal T cell expressed and presumably secreted), macrophage inflammatory proteins (e.g., MIP-1 alpha and MIP-1 beta), and Leishmania elongation initiating factor (LEIF)); bacterial components (e.g., endotoxins, in particular superantigens, exotoxins and cell wall components); aluminum-based salts; calcium-based salts; silica; polynucleotides; toxoids;

10 serum proteins, viral coat proteins; block copolymer adjuvants (e.g., Hunter's Titermax<sup>TM</sup> adjuvant (Vaxcel<sup>TM</sup>, Inc. Norcross, GA), Ribi adjuvants (Ribi ImmunoChem Research, Inc., Hamilton, MT); and saponins and their derivatives (e.g., Quil A (Superfos Biosector A/S, Denmark). Protein adjuvants of the present invention can be delivered in the form of the protein themselves or of nucleic acid molecules encoding such proteins using the

15 methods described herein.

In one embodiment of the present invention, a therapeutic composition can include a carrier. Carriers include compounds that increase the half-life of a therapeutic composition in the treated animal. Suitable carriers include, but are not limited to, polymeric controlled release vehicles, biodegradable implants, liposomes, bacteria,

20 viruses, other cells, oils, esters, and glycols.

One embodiment of the present invention is a controlled release formulation that is capable of slowly releasing a composition of the present invention into an animal. As

used herein, a controlled release formulation comprises a composition of the present invention in a controlled release vehicle. Suitable controlled release vehicles include, but are not limited to, biocompatible polymers, other polymeric matrices, capsules, microcapsules, microparticles, bolus preparations, osmotic pumps, diffusion devices, liposomes, lipospheres, and transdermal delivery systems. Other controlled release formulations of the present invention include liquids that, upon administration to an animal, form a solid or a gel *in situ*. Preferred controlled release formulations are biodegradable (i.e., bioerodible).

A preferred controlled release formulation of the present invention is capable of releasing a composition of the present invention into the blood of the treated animal at a constant rate sufficient to attain therapeutic dose levels of the composition to protect an animal from flea infestation. The therapeutic composition is preferably released over a period of time ranging from about 1 to about 12 months. A controlled release formulation of the present invention is capable of effecting a treatment preferably for at least about 1 month, more preferably for at least about 3 months, even more preferably for at least about 6 months, even more preferably for at least about 9 months, and even more preferably for at least about 12 months.

Acceptable protocols to administer therapeutic compositions in an effective manner include individual dose size, number of doses, frequency of dose administration, and mode of administration. Determination of such protocols can be accomplished by those skilled in the art. A suitable single dose is a dose that is capable of protecting an animal from disease when administered one or more times over a suitable time period.

For example, a preferred single dose of a protein, mimetope or antibody therapeutic composition, including a recombinant protein vaccine, is from about 1 microgram ( $\mu\text{g}$ ) to about 10 milligrams (mg) of the therapeutic composition per kilogram body weight of the animal. Booster vaccinations can be administered from about 2 weeks to several years after the original administration. Booster administrations preferably are administered when the immune response of the animal becomes insufficient to protect the animal from disease. A preferred administration schedule is one in which from about 10  $\mu\text{g}$  to about 1 mg of the therapeutic composition per kg body weight of the animal is administered from about one to about two times over a time period of from about 2 weeks to about 12 months. Modes of administration can include, but are not limited to, subcutaneous, intradermal, intravenous, intranasal, oral, transdermal, intraocular, intranasal, conjunctival, and intramuscular routes. Methods of administration for other therapeutic compounds can be determined by one skilled in the art, and may include administration of a therapeutic composition one or more times, on a daily, weekly, monthly or yearly regimen; routes of administration can be determined by one skilled in the art, and may include any route. A preferred route of administration of an inhibitory compound when administering to fleas is a topical, or "spot-on" formulation administered to the body surface of the animal, so that a flea would encounter the inhibitory compound when attached to the animal; another preferred route of administration of an inhibitory compound is an oral formulation that, when fed to an animal, would enter the bloodstream of the animal, which would then be transferred to a flea while feeding from the animal.

5 A recombinant protein vaccine of the present invention comprises a recombinantly-produced flea HMT and/or HNC protein of the present invention that is administered to an animal according to a protocol that results in the animal producing a sufficient immune response to protect itself from a flea infestation. Such protocols can be determined by those skilled in the art.

10 According to one embodiment, a nucleic acid molecule of the present invention can be administered to an animal in a fashion to enable expression of that nucleic acid molecule into a protective protein or protective RNA (e.g., antisense RNA, ribozyme, triple helix forms or RNA drug) in the animal. Nucleic acid molecules can be delivered to an animal in a variety of methods including, but not limited to, (a) administering a naked (i.e., not packaged in a viral coat or cellular membrane) nucleic acid as a genetic vaccine (e.g., as naked DNA or RNA molecules, such as is taught, for example in Wolff et al., 1990, *Science* 247, 1465-1468) or (b) administering a nucleic acid molecule packaged as a recombinant virus vaccine or as a recombinant cell vaccine (i.e., the  
15 nucleic acid molecule is delivered by a viral or cellular vehicle).

A genetic (i.e., naked nucleic acid) vaccine of the present invention includes a nucleic acid molecule of the present invention and preferably includes a recombinant molecule of the present invention that preferably is replication, or otherwise amplification, competent. A genetic vaccine of the present invention can comprise one or  
20 more nucleic acid molecules of the present invention in the form of, for example, a dicistronic recombinant molecule. Preferred genetic vaccines include at least a portion of a viral genome, i.e., a viral vector. Preferred viral vectors include those based on



alphaviruses, poxviruses, adenoviruses, herpesviruses, picornaviruses, and retroviruses, with those based on alphaviruses, such as sindbis or Semliki forest virus, species-specific herpesviruses and poxviruses being particularly preferred. Any suitable transcription control sequence can be used, including those disclosed as suitable for protein production.

5 Particularly preferred transcription control sequences include cytomegalovirus immediate early (preferably in conjunction with Intron-A), Rous sarcoma virus long terminal repeat, and tissue-specific transcription control sequences, as well as transcription control sequences endogenous to viral vectors if viral vectors are used. The incorporation of a "strong" polyadenylation signal is also preferred.

10 Genetic vaccines of the present invention can be administered in a variety of ways, with intramuscular, subcutaneous, intradermal, transdermal, conjunctival, intraocular, intranasal and oral routes of administration being preferred. A preferred single dose of a genetic vaccine ranges from about 1 nanogram (ng) to about 600 µg, depending on the route of administration and/or method of delivery, as can be determined  
15 by those skilled in the art. Suitable delivery methods include, for example, by injection, as drops, aerosolized and/or topically. Genetic vaccines of the present invention can be contained in an aqueous excipient (e.g., phosphate buffered saline) alone or in a carrier (e.g., lipid-based vehicles).

A recombinant virus vaccine of the present invention includes a recombinant  
20 molecule of the present invention that is packaged in a viral coat and that can be expressed in an animal after administration. Preferably, the recombinant molecule is packaging- or replication-deficient and/or encodes an attenuated virus. A number of

recombinant viruses can be used, including, but not limited to, those based on alphaviruses, poxviruses, adenoviruses, herpesviruses, picornaviruses, and retroviruses. Preferred recombinant virus vaccines are those based on alphaviruses (such as Sindbis virus), raccoon poxviruses, species-specific herpesviruses and species-specific poxviruses. An example of methods to produce and use alphavirus recombinant virus vaccines are disclosed in U.S. Patent No. 5,766,602 to Xiong and Grieve, which is incorporated by reference herein in its entirety.

When administered to an animal, a recombinant virus vaccine of the present invention infects cells within the immunized animal and directs the production of a protective protein or RNA nucleic acid molecule that is capable of protecting the animal from flea infestation as disclosed herein. For example, a recombinant virus vaccine comprising a flea HMT and/or HNC nucleic acid molecule of the present invention is administered according to a protocol that results in the animal producing a sufficient immune response to protect itself from flea infestation. A preferred single dose of a recombinant virus vaccine of the present invention is from about  $1 \times 10^4$  to about  $1 \times 10^8$  virus plaque forming units (pfu) per kilogram body weight of the animal. Administration protocols are similar to those described herein for protein-based vaccines, with subcutaneous, intramuscular, intranasal, intraocular, conjunctival, and oral administration routes being preferred.

A recombinant cell vaccine of the present invention includes recombinant cells of the present invention that express at least one protein of the present invention. Preferred recombinant cells for this embodiment include *Salmonella*, *E. coli*, *Listeria*,

*Mycobacterium*, *S. frugiperda*, yeast, (including *Saccharomyces cerevisiae* and *Pichia pastoris*), BHK, CV-1, myoblast G8, COS (e.g., COS-7), Vero, MDCK and CRFK recombinant cells. Recombinant cell vaccines of the present invention can be administered in a variety of ways but have the advantage that they can be administered orally, preferably at doses ranging from about  $10^8$  to about  $10^{12}$  cells per kilogram body weight. Administration protocols are similar to those described herein for protein-based vaccines. Recombinant cell vaccines can comprise whole cells, cells stripped of cell walls or cell lysates.

The efficacy of a therapeutic composition of the present invention to protect an animal from flea infestation can be tested in a variety of ways including, but not limited to, detection of protective antibodies (using, for example, proteins or mimetopes of the present invention), detection of cellular immunity within the treated animal, or challenge of the treated animal with the fleas to determine whether the treated animal is resistant to infestation. Challenge studies can include direct administration of fleas to the treated animal. In one embodiment, therapeutic compositions can be tested in animal models such as mice. Such techniques are known to those skilled in the art.

One therapeutic composition of the present invention includes an inhibitor of flea HMT and/or HNC protein activity, i.e., a compound capable of substantially interfering with the function of a flea HMT and/or HNC protein susceptible to inhibition by an inhibitor of flea HMT and/or HNC protein activity. An inhibitor of HMT and/or HNC protein activity can be identified using flea HMT and/or HNC proteins of the present invention. An inhibitor of HMT and/or HNC protein function can be identified using flea

HMT and/or HNC proteins of the present invention. A preferred inhibitor of HMT and/or HNC protein function is a compound capable of substantially interfering with the function of a flea HMT and/or HNC protein and which does not substantially interfere with host animal proteins. As used herein, a compound that does not substantially inhibit or interfere with host animal proteins is one that, when administered to a host animal, the host animal shows no significant adverse effects attributable to the compound and which, when administered to an animal in an effective manner, is capable of protecting that animal from flea infestation.

One embodiment of the present invention is a method to identify a compound capable of inhibiting HMT and/or HNC protein activity of a flea. Such a method includes the steps of (a) contacting (e.g., combining, mixing) an isolated flea HMT and/or HNC protein, preferably a *C. felis* HMT and/or HNC protein of the present invention, with a putative inhibitory compound under conditions in which, in the absence of the compound, the protein has HMT and/or HNC protein activity, and (b) determining if the putative inhibitory compound inhibits the activity. HMT and/or HNC protein activity can be determined in a variety of ways known in the art, including but not limited to determining the ability of HMT and/or HNC protein to bind to or otherwise interact with a substrate. Such conditions under which a HMT and/or HNC protein has HMT and/or HNC protein activity include conditions in which a HMT and/or HNC protein has a correct three-dimensionally folded structure under physiologic conditions, i.e. physiologic pH, physiologic ionic concentrations, and physiologic temperatures.

Putative inhibitory compounds to screen include antibodies (including fragments and mimetopes thereof), putative substrate analogs, and other, preferably small, organic or inorganic molecules. Methods to determine HMT and/or HNC protein activity are known to those skilled in the art; see, for example, the Examples section of the present application. Methods to determine binding of a putative inhibitory compound to a HMT and/or HNC protein of the present invention are known to those of skill in the art and include, for example, determining changes in molecular mass using surface plasmon resonance (e.g., determining light scatter by an inhibitor of a HMT and/or HNC protein, before and after contacting the inhibitor or protein with a HMT and/or HNC protein or inhibitor, respectively) or screening for compounds that inhibit interaction between a HMT and/or HNC protein and a substrate.

A preferred method to identify a compound capable of inhibiting HMT and/or HNC protein activity includes contacting an isolated flea HMT and/or HNC protein having an amino acid sequence selected from the group consisting of: (a) a protein comprising an amino acid sequence selected from the group consisting of SEQ ID NO:2, SEQ ID NO:8, SEQ ID NO:14, SEQ ID NO:20, SEQ ID NO:26, SEQ ID NO:32, SEQ ID NO:38, SEQ ID NO:44, SEQ ID NO:154, SEQ ID NO:160, SEQ ID NO:163, SEQ ID NO:169, SEQ ID NO:1862, SEQ ID NO:1868, SEQ ID NO:1873, SEQ ID NO:1879, SEQ ID NO:1883, SEQ ID NO:1888, SEQ ID NO:1897, SEQ ID NO:1902, SEQ ID NO:1915, SEQ ID NO:1920, SEQ ID NO:1925, and/or SEQ ID NO:1930, and/or a protein encoded by a nucleic acid molecule of Table I, Table II, Table III and/or Table IV; (b) a protein comprising an at least 25 consecutive amino acid portion identical in

sequence to a consecutive amino acid portion of a sequence as set forth in (a), wherein the protein has HMT and/or HNC protein activity; (c) a protein comprising a fragment of a protein as set forth in (a), wherein the fragment has an activity selected from the group consisting of binding to a HMT and/or HNC molecule and hydrolyzing a HMT and/or HNC protein substrate; and (d) a protein encoded by an allelic variant of a nucleic acid molecule that encodes any protein of (a), (b), or (c), with a putative inhibitory compound under conditions in which, in the absence of the compound, the protein has HMT and/or HNC protein activity; and determining if the putative inhibitory compound inhibits the activity.

Another embodiment of the present invention is an assay kit to identify an inhibitor of a flea HMT and/or HNC protein of the present invention. This kit comprises an isolated flea HMT and/or HNC protein of the present invention, and a means for determining inhibition of an activity of flea HMT and/or HNC protein, where the means enables detection of inhibition. Detection of inhibition of flea HMT and/or HNC protein identifies a putative inhibitor to be an inhibitor of flea HMT and/or HNC protein. Means for determining inhibition of flea HMT and/or HNC protein include an assay system that detects binding of a putative inhibitor to a flea HMT and/or HNC molecule, and an assay system that detects interference by a putative inhibitor of the ability of flea HMT and/or HNC protein to hydrolyze a substrate. Means and methods are described herein and are known to those skilled in the art.

The following examples are provided for the purposes of illustration and are not intended to limit the scope of the present invention. The following examples include a

number of recombinant DNA and protein chemistry techniques known to those skilled in the art; see, for example, Sambrook et al., *ibid*.

### Example 1

This Example describes the isolation of RNA from the hindgut and Malpighian tubules (HMT) of *Ctenocephalides felis* and the use of isolated RNA to construct subtracted and unsubtracted cDNA libraries.

Approximately 10,000 hindguts and Malpighian tubules were dissected from equal numbers of cat blood fed and unfed adult *C. felis* with a male to female ratio of 1 to 4, and total RNA was extracted using a guanidine isothiocyanate lysis buffer and the standard procedure described by Sambrook et al. Poly-A enriched mRNA was purified from total RNA above using a mRNA Purification Kit, available from Pharmacia Biotech, Piscataway, NJ, following the manufacturer's protocol. The same procedures were used to extract total RNA and isolate poly-A enriched mRNA from the dissected *C. felis* bodies following removal of HMT, referred to hereinafter as "non-HMT mRNA".

Poly-A enriched mRNA was used to construct a cDNA library using subtractive hybridization and suppression PCR as follows. Subtractive hybridization and suppression PCR was conducted using a PCR-Select™ cDNA Subtraction Kit, available from Clontech Laboratories, Inc., Palo Alto, CA according to the manufacturer's instructions. Briefly, this kit uses subtractive hybridization and suppression PCR to specifically amplify cDNA sequences that are present in the tester cDNA and absent in the driver cDNA, thus enriching for tester-specific sequences. The efficiency of the subtraction process can be assessed by semi-quantitative PCR and by comparing the ethidium

bromide staining patterns of the subtracted and unsubtracted samples on agarose gels as described in section V.D. of the manufacturer's protocol. For the semi-quantitative PCR, three genes with mRNAs known to be expressed outside of the HMT tissue were used to test for specific subtraction. These genes encoded putative actin, N-aminopeptidase, and  
 5 serine protease proteins.

Subtractive hybridization and suppression PCR was conducted under the following conditions. Two micrograms ( $\mu\text{g}$ ) of HMT mRNA was used as the template for synthesis of the tester material and 2  $\mu\text{g}$  of non-HMT mRNA was used as template for synthesis of the driver material in this reaction. The number of cycles used in the  
 10 selective amplification steps was optimized using the manufacturer's protocols. Optimization resulted in the use of 24 rather than the standard 27 cycles of primary PCR in combination with 15 cycles of secondary PCR rather than the standard 12 cycles.

The products from the suppressive PCR reaction were ligated into the pCR@2.1 vector, available from Invitrogen, Carlsbad, CA, using an Original TA Cloning® Kit,  
 15 available from Invitrogen. The ligation reaction was then used to transform INV $\alpha$ F' One Shot™ competent cells, available from Invitrogen, which were plated on Luria broth (LB) agar with 50 micrograms per milliliter ( $\mu\text{g}/\text{ml}$ ) ampicillin, available from Sigma-Aldrich Co., St. Louis, MO, and 50  $\mu\text{g}/\text{ml}$  5-bromo-4-chloro-3-indoyl  $\beta$ -D-galactopyranoside (X-Gal), available from Fisher Biotech, Fair Lawn, NJ. Transformed colonies were  
 20 amplified and the DNA isolated using the standard alkaline lysis procedure described by Sambrook et al., *ibid*.



Automated cycle sequencing of DNA samples was performed using an ABI PRISM™ Model 377, available from Perkins Elmer, with XL upgrade DNA Sequencer, available from PE Applied Biosystems, Foster City, CA, after reactions were carried out using the PRISM™ Dye Terminator Cycle Sequencing Ready Reaction Kit or the PRISM™ dRhodamine Terminator Cycle Sequencing Ready Reaction Kit or the PRISM™ BigDye™ Terminator Cycle sequencing Ready Reaction Kit, available from PE Applied Biosystems, following the manufacturer's protocol, hereinafter "standard sequencing methods". Sequence analysis was performed using the MacVector™ sequence analysis software, available from International Biotechnologies Inc., New Haven, CT, and the Wisconsin Package Version 9.0 sequence analysis software, available from Genetics Computer Group (GCG), Madison, WI, hereinafter referred to as GCG version 9.0, using default parameters. Each sequence read was trimmed of vector sequence at either end and submitted for a search through the National Center for Biotechnology Information (NCBI), National Library of Medicine, National Institute of Health, Baltimore, MD, using the BLAST network. This database includes SwissProt + PIR + SPupdate + GenPept + GPCupdate + PDB databases. The search was conducted using the xBLAST function, which compares the translated sequences in all 6 reading frames to the protein sequences contained in the database. Clones with significant homology to sequences in the GenBank database were grouped according to proposed function and are listed in Table II. Clones with no significant homology to sequences in the GenBank database were searched manually for open reading frames and are listed in Table IV.

- An unsorted HMT cDNA library was constructed as follows. Approximately 10,000 HMT tissues were dissected from equal numbers of unfed and cat blood-fed adult *C. felis* with a male to female ratio of 1:4. Total RNA was extracted using a guanidine isothiocyanate lysis buffer and procedures described in Sambrook et al., followed by
- 5 isolation using a mRNA purification kit, available from Pharmacia, according to the manufacturer's protocols. The library was constructed with 5 µg of isolated mRNA using a ZAP-cDNA® cDNA synthesis kit, and packaged using a ZAP-cDNA® Gigapack® gold cloning kit, both available from Stratagene, La Jolla, CA. The resultant HMT library was amplified to a titer of about  $5 \times 10^9$  plaque forming units per milliliter (pfu/ml).
- 10 Single clone excisions were performed using the Ex-Assist™ helper phage, available from Stratagene, and used to create double stranded plasmid template for sequencing using the manufacturer's protocols with the following exceptions. Following incubation of the SOLR cells with the cleared phage lysate, the mixture was used to inoculate LB broth, and the mix was incubated overnight and then subjected to mini-prep plasmid
- 15 preparation and sequencing as described for the subtracted HMT library above.

#### Example 2

This Example describes the isolation of RNA from the head and nerve cord (HNC) of *Ctenocephalides felis* and the use of isolated RNA to construct subtracted and unsorted cDNA libraries.

- 20 Approximately 4,000 heads and attached nerve cords, including the terminal abdominal ganglia were dissected from equal numbers of cat blood-fed and unfed adult *C. felis* with a male to female ratio of 1 to 4, and total RNA was extracted using a

guanine isothiocyanate lysis buffer and the standard procedure described by Sambrook et al. Approximately 618 µg of total RNA was recovered. Poly-A enriched mRNA was purified from total RNA above using a mRNA Purification Kit, available from Pharmacia, following the manufacturer's protocol. Approximately 13 µg of mRNA was isolated. The same procedures were used to extract total RNA and isolate poly-A enriched mRNA from the dissected *C. felis* bodies following removal of HNC tissues, referred to hereinafter as "non-HNC mRNA".

Suppression subtractive PCR was conducted as described in Example 1 using a PCR-Select™ cDNA Subtraction kit, available from Clontech, under the following conditions. Two micrograms (µg) of HNC mRNA was used as the template for synthesis of the tester material and 2 µg of non-HMT mRNA was used as template for synthesis of the driver material in this reaction. The number of cycles used in the selective amplification steps was optimized using the manufacturer's protocols. Optimization resulted in the use of 24 rather than the standard 27 cycles of primary PCR in combination with either 12 or 15 cycles of secondary PCR.

cDNA pools from various PCR cycling combinations were ligated into the TA vector using a TA cloning kit, available from Invitrogen. Aliquots of ligation reaction were transformed into Ultramax DH5α™ bacteria, available from Gibco-BRL, Gaithersburg, MD. Portions of the transformation mixes were used to inoculate LB broth cultures containing 100 µg/ml of ampicillin. The overnight cultures were plated to generate discreet colonies which were used individually for overnight cultures for

plasmid preps. Transformed colonies were amplified and the DNA isolated using the standard alkaline lysis procedure described by Sambrook et al., *ibid*.

Automated cycle sequencing of DNA samples was performed using the standard sequencing methods described in Example 1. Sequence analysis was performed using the  
5 MacVector™ sequence analysis software, available from International Biotechnologies Inc., New Haven, CT, and the Wisconsin Package Version 9.0 sequence analysis software, available from Genetics Computer Group (GCG), Madison, WI, hereinafter referred to as GCG version 9.0, using default parameters. Each sequence read was trimmed of vector sequence at either end and submitted for a xBLAST search as  
10 described in Example 1. Clones with significant homology to sequences in the GenBank database were grouped according to proposed function and are listed in Table I. Clones with no significant homology to sequences in the GenBank database were searched manually for open reading frames and are listed in Table III.

An unsubtracted cDNA library was constructed as follows. Approximately 6400  
15 head and nerve cords were dissected from *C. felis* and poly-A RNA was isolated as described above. About seven µg of HNC poly-A RNA was used to construct a cDNA library using Stratagene's λZAP-cDNA Synthesis Kit and protocol. The resultant HNC library was amplified to a titer of about  $5 \times 10^9$  plaque forming units per milliliter (pfu/ml). Single clone excisions were performed using the Ex-Assist helper phage,  
20 available from Stratagene, and used to create double stranded plasmid template for sequencing using the manufacturer's protocols with the following exceptions. Following incubation of the SOLR cells with the cleared phage lysate, the mixture was used to

inoculate LB broth, and the mix was incubated overnight and then subjected to mini-prep plasmid preparation and sequencing as described for the subtracted library above.

### Example 3

This example describes the production of a *C. felis* cDNA pool by Rapid

#### 5 Amplification of cDNA Ends (RACE cDNA pool).

Total RNA was extracted from adult fed and unfed fleas as follows.

Approximately 1000 adult fed fleas and 1000 adult unfed fleas were frozen on dry ice and separately ground into powder using a mortar and pestle and total RNA was extracted from each powder as follows. Ten ml of solution D (4 M guanidine isothiocyanate, 25  
10 mM Sodium Citrate pH 7.0, 1.5% Sarcosyl, 0.5 M 2-mercaptoethanol) were added to the powder and the suspension was mixed by shaking. One ml of 2M sodium acetate, pH 4.0 and 3 ml of pH 4.7 phenol/chloroform/isoamyl alcohol (125:24:1), available from Sigma, were added and the suspension was mixed on a vortex shaker then incubated on ice for 15 minutes. Following incubation, the mixture was centrifuged at 10,000 X g for 20 minutes  
15 and the supernatant was removed and extracted twice with pH 4.7 phenol/chloroform/isoamyl alcohol. Next, an equal volume of isopropanol was added to the supernatant and incubated at -20°C for 2 hours followed by centrifugation at 10,000 X g for 20 minutes. Following centrifugation, the supernatant was removed and discarded and the pellet was washed in 70% ethanol and allowed to dry at room temperature. The  
20 pellet was resuspended in 10 mM Tris 1 mM EDTA pH 8.0. Spectrophotometer analysis indicated that the yield of total RNA from unfed fleas was 1140 µg and the yield from fed fleas was 1500 µg.

Six-hundred µg from each of the fed and unfed adult flea total RNA extractions were combined and mRNA was then extracted using a mRNA Purification Kit, available from Amersham Pharmacia Biotech, Piscataway, NJ, using the manufacture's protocol. Approximately 15-25 µg of mRNA were isolated based on spectrophotometer analysis and ethidium bromide staining. One µg of purified mRNA was used as template to construct a RACE cDNA pool using a Marathon cDNA Amplification Kit, available from Clontech Laboratories, Inc., Palo Alto, CA, according to the manufacture's instructions.

#### Example 4

This example describes the cloning, sequencing, recombinant protein expression and purification of a *C. felis* allantoinase nucleic acid molecule of the present invention. This example also describes the expression of allantoinase mRNA in a variety of flea tissues.

A TA clone from the HMT EST library described in Example 1 was sequenced using standard sequencing methods and shown to have significant homology to allantoinase genes. This clone was digested with *Eco*RI to excise an insert 682 nucleotides in length, referred to as flea nucleic acid molecule nCfALN<sub>682</sub>. The insert was isolated by gel purification using a Gel Purification kit, available from Qiagen, Chatsworth, CA. Approximately 50 nanograms (ng) of purified nCfALN<sub>682</sub> was used to construct a <sup>32</sup>P α-dATP labeled DNA probe using a Megaprime DNA labeling kit, available from Amersham, Arlington Heights, IL, using the manufacturer's protocols.

The <sup>32</sup>P α-dATP labeled probe was used in a standard plaque lift hybridization procedure to isolate a clone from the HMT lambda-ZAP unsubtracted cDNA library described in Example 1. The following hybridization conditions were used, hereinafter

referred to as "standard hybridization conditions". Filters were hybridized with about 1 X 10<sup>6</sup> counts per minute (cpm) per ml of the probe in 5X SSPE, (see Sambrook et al., *ibid.*), 1.2% sodium dodecyl sulfate (SDS), 0.1 mg/ml salmon sperm DNA and 5X Denhardt's reagent, (see Sambrook et al., *ibid.*), at 55°C for about 14 hours. The filters

5 were washed as follows: (a) 10 minutes with 5X SSPE and 1% SDS, (b) 10 minutes with 2X SSPE and 1% SDS, (c) 10 minutes with 1X SSPE and 0.5% SDS, and (d) 10 minutes with 0.5X SSPE and 1% SDS. All washes were conducted at 55°C. Plaques that hybridized strongly to the probe were isolated and subjected to *in vivo* excision. *In vivo* excision was performed using the Stratagene Ex-Assist™ helper phage system and

10 protocols, to convert a positive plaque to pBluescript™ plasmid DNA. Sequencing was conducted using standard sequencing methods following preparation of DNA with a Qiagen Qiaprep™ spin mini prep kit using the manufacturer's instructions and restriction enzyme digestion with about 1 µl of 20 U/µl each of *Eco*RI and *Xho*I, available from New England Biolabs, Beverly, MA. A clone was isolated from a primary plaque, containing a

15 nucleic acid molecule of about 2057 base pairs, referred to herein as nCfALN<sub>2057</sub>, having a nucleotide sequence denoted herein as SEQ ID NO:1. The complement of SEQ ID NO:1 is represented herein as SEQ ID NO:3. Sequencing of nCfALN<sub>682</sub> indicates that nCfALN<sub>682</sub> shared 100% identity with nucleotides 855 through 1536 of SEQ ID NO:1.

Translation of SEQ ID NO:1 suggests that nucleic acid molecule nCfALN<sub>2057</sub>

20 encodes a full-length allantoinase protein of 384 amino acids, referred to herein as PCfALN<sub>384</sub>, having an amino acid sequence represented by SEQ ID NO:2, assuming the initiation codon spans from nucleotide 152 through nucleotide 154 of SEQ ID NO:1 and

the termination codon spans from nucleotide 1304 through nucleotide 1306 of SEQ ID NO:1. The coding region encoding PCfALN<sub>384</sub>, is represented by nucleic acid molecule nCfALN<sub>1152</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:4 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:6. The amino acid sequence of PCfALN<sub>384</sub>, also represented as SEQ ID NO:5, predicts that PCfALN<sub>384</sub> has an estimated molecular weight of about 42.2 kilodaltons (kDa) and an estimated isoelectric point (pI) of about 6.

Comparison of amino acid sequence SEQ ID NO:2 with amino acid sequences reported in GenBank indicates that SEQ ID NO:2 showed the most homology, i.e., about 48.6% identity, with a *Rana catesbeiana* (bullfrog) allantoinase protein, GenBank Accession No. 458126. Comparison of SEQ ID NO:4 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:4 showed the most homology, i.e., about 51% identity, with a *Rana catesbeiana* nucleic acid molecule, GenBank Accession number U03471. Percent identity calculations were performed using GCG version 9.0 using default parameters.

The coding region of nCfALN<sub>2057</sub>, i.e. SEQ ID NO:4, was PCR amplified from the pBluescript™ clone described above as the template, using sense primer ALN-FE, having nucleotide sequence 5' GCG **GAT CCT** ATG CTG AAT TGC AAG AAC CTT G 3', having a *Bam*HI site indicated in bold, designated herein as SEQ ID NO:37, and anti-sense primer ALN-RE, having nucleotide sequence 5' CAG **GTA CCC** TCT TTT AGA AGC ACC GGT CCC 3', having a *Kpn*I site indicated in bold, designated herein as SEQ ID NO:38. PCR reactions were performed using the following amplification cycles: (a)



one cycle at 95°C for thirty seconds; (b) thirty cycles at 95°C for twenty seconds, 50°C for twenty seconds, and 72°C for two minutes; and (c) one cycle at 72°C for five minutes, hereinafter referred to as “standard thermocycling conditions”, in reactions containing 2.5 mM MgCl<sub>2</sub>, 0.2 mM dNTPs, 1 μM of each primer, 0.5 μl of 5U/μl *Taq* polymerase, 1 μl of 1 μg/μl template, and 3 μl of 10X *Taq* buffer, hereinafter referred to as “standard PCR reaction conditions”. The PCR product was digested with *Bam*HI and *Kpn*I and ligated into the vector pTrcHisB, available from Invitrogen, that had been digested with *Bam*HI and *Kpn*I and treated with alkaline phosphatase. The resulting recombinant molecule, referred to herein as pTrc-nCfALN<sub>1152</sub>, was transformed into *E. coli* strain BL21, available from Novagen Inc., Madison, WI, to form recombinant cell *E. coli*:pTrc-nCfALN<sub>1152</sub>.

The recombinant cell was grown under standard conditions and then incubated in the presence of 0.5 μM isopropylthio-β-galactoside (IPTG) to induce expression of recombinant protein, predicted to be approximately 42.2 kDa. Expression was confirmed using Coomassie-blue-stained Tris-glycine gel and by Western blot using a T7 tag antibody, available from Novagen, which showed expression of an about 55-kDa protein. The protein product was purified by liquid chromatography using a HiTrap™ chelating column charged with NiCl<sub>2</sub>, available from Pharmacia, and was shown to contain the His tag of the vector when subjected to automated protein sequencing by Edman degradation.

A Northern Blot analysis was conducted as follows to determine whether allantoinase is expressed exclusively in HMT tissues. HMT tissues were dissected from 1000 adult cat blood-fed *C. felis* having a male to female ratio of 1:4. Total RNA was

separately extracted from HMT tissues and the HMT-less carcasses that resulted from these dissections as follows. The tissues were frozen at -80°C, ground into a powder with a mortar and pestle, and the powders were equally divided into four 2-ml eppendorf tubes each containing 1 ml of lysis buffer. The lysis buffer contained 4 M guanidinium

5 thiocyanate, 25 mM sodium citrate, pH 7.0, 3% sarcosyl, 0.5M 2-mercaptoethanol, 0.1% antifoam, and 1 mM aurintricarboxylic acid, all available from Sigma Chemical Corporation, St. Louis, MO. After mixing, the tubes were spun at 14,000 rpm for 2 minutes and the supernatants were transferred to separate 2 ml eppendorf tubes containing 250 µl of phenol, available from Aldrich, Milwaukee, WI. After mixing, the

10 tubes were spun at 14,000 rpm for 5 minutes and the supernatants were transferred to new 2-ml tubes. This process was repeated 3 times until no proteinaceous matter was visible at the phenol/lysis buffer interface, then 250 µl of chloroform was added to each tube and the contents mixed and spun at 14,000 rpm for 5 minutes followed by transferring the supernatant to a new tube. A volume of isopropanol equal to the volume of the

15 supernatant was added to each tube and the tubes placed on ice for 5 minutes. The tubes were then spun at 14,000 rpm at room temperature for 15 minutes, the supernatants were removed and discarded and the remaining RNA pellets were washed with 70% ethanol and dried. The RNA pellets were resuspended in 100 µl of TE (10 mM Tris, 1 mM ethylenediaminetetraacetic acid (EDTA)). The quantity of RNA in each tube was then

20 determined using a spectrophotometer.

Approximately 10 µg of each RNA was added to separate tubes containing 18.75 µl of loading buffer, which consists of 50% formamide, 16% formaldehyde, 17%

water, 7% glycerol, 1 X MOPS buffer (a 1:20 dilution of 0.4 M 93-[N-morpholino]propanesulfonic acid (MOPS), 0.1 M sodium acetate, and 20 mM EDTA), 10  $\mu$ l ethidium bromide, and 10  $\mu$ l bromophenol blue dye, all available from Sigma. The tubes were heated to 95°C for 2 minutes then placed on ice. The RNA samples were

5 separated by gel electrophoresis on a 1.5% agarose gel with 3.2% formaldehyde and 1 X MOPS buffer; the gel was then soaked in water for 30 minutes prior to transfer to remove excess formaldehyde. The gel was then transferred using standard techniques, described by Sambrook *et al.*, *ibid*, with 10 X SSPE as the transfer buffer onto Nytran® nylon membrane, available from Schleicher and Schuell Inc., Keene, NH. The membrane

10 was UV cross-linked using the Stratalinker®, available from Stratagene, then prehybridized at 42°C in 50% formamide, 5X SSPE, 1.2% SDS, 5X Denhardt's reagent, 2.5 mM EDTA, and 100  $\mu$ g/ml salmon sperm DNA. A probe comprising the allantoinase EST nucleic acid molecule, nCfALN<sub>682</sub> was labeled with  $\alpha$ -<sup>32</sup>P-ATP using a DNA labeling kit, available from Amersham and added to the buffer at a concentration of

15 approximately  $1 \times 10^6$  cpm/ml, and allowed to hybridize for 18 hours at 42°C. The blot was then washed as follows: 10 minutes at 42°C in 4X SSPE and 1% SDS; 10 minutes at 42°C in 2X SSPE and 1% SDS; 10 minutes at 42°C with 0.5X SSPE and 0.5X SDS; and 10 minutes at 42°C with 0.25X SSPE and 0.25% SDS. The blot was then exposed to film for 1 hour, and the film was developed using standard procedures. Analysis of the

20 developed film revealed that allantoinase mRNA was present in HMT tissues but was not present in non-HMT tissues.

Northern Blot analysis was also conducted to determine whether allantoinase mRNA is expressed only in certain stages of the flea life cycle and whether allantoinase mRNA expression is influenced by feeding. Total RNA was extracted as described above from 1000 fleas at each of the following flea life stages; eggs, first instar larvae, third  
 5 instar larvae, wandering larvae and pupae and from 1000 adult fleas under the following feeding conditions; unfed, fed on cat blood for 15 minutes, fed on cat blood for 2 hours, fed on cat blood for 8 hours, and fed on cat blood for 24 hours.

Each RNA sample was separated by gel electrophoresis, transferred to nylon membrane and hybridized with  $\alpha$ -<sup>32</sup>P-ATP labeled nCfALN<sub>682</sub> probe as described above.  
 10 Analysis of the developed film revealed that allantoinase mRNA was expressed in all adult fleas tested regardless of feeding conditions and was expressed by all life stages except for eggs and pupae, the two life stages which do not feed or excrete urine.

#### Example 5

This example describes the cloning, sequencing, recombinant protein expression  
 15 and purification of a *C. felis* chitin-binding protein nucleic acid molecule. This example also describes the expression of chitin-binding protein mRNA in a variety of flea tissues.

A TA clone from the HMT EST library described in Example 1 was sequenced using standard sequencing methods and shown to have homology to a chitinase-like gene from *Bombyx mori* (silkworm). This clone was digested with *EcoRI* to excise an insert  
 20 about 429 nucleotides in length, referred to as chitin-binding protein (CBP) nucleic acid molecule nCfCBP<sub>429</sub>. The insert was isolated by gel purification using a Gel Purification kit, available from Qiagen. Approximately 50 ng of purified nCfCBP<sub>429</sub> was used to

construct a  $^{32}\text{P}$   $\alpha$ -dATP labeled DNA probe using a Megaprime DNA labeling kit, available from Amersham, using the manufacturer's protocols.

The  $^{32}\text{P}$   $\alpha$ -dATP labeled probe was used in a plaque lift hybridization procedure to isolate a clone from the HMT lambda-ZAP unsubtracted cDNA library described in

- 5 Example 1, using standard hybridization conditions described in Example 4. Plaques that hybridized strongly to the probe were isolated and subjected to *in vivo* excision. *In vivo* excision was performed using the Stratagene Ex-Assist™ helper phage system and protocols, to convert a positive plaque to pBluescript™ plasmid DNA, and sequencing was conducted following preparation of DNA with a Qiagen Qiaprep™ spin mini prep kit
- 10 using the manufacturer's instructions and restriction enzyme digestion with about 1  $\mu\text{l}$  of 20 U/ $\mu\text{l}$  each of *EcoRI* and *XhoI*, available from New England Biolabs. A clone was isolated from a primary plaque, containing a nucleic acid molecule of about 1128 base pairs, referred to herein as nCfCBP<sub>1128</sub>, having a nucleotide sequence denoted herein as SEQ ID NO:7. The complement of SEQ ID NO:7 is represented herein as SEQ ID NO:9.
- 15 Sequencing of nCfCBP<sub>429</sub> indicated that nCfCBP<sub>429</sub> shares 100% identity with nucleotides 148 through 576 of SEQ ID NO:7.

- 20 Translation of SEQ ID NO:7 suggests that nucleic acid molecule nCfCBP<sub>1128</sub> encodes a full-length chitin-binding protein of 272 amino acids, referred to herein as PCfCfCBP<sub>272</sub>, having an amino acid sequence represented by SEQ ID NO:8, assuming the initiation codon spans from nucleotide 6 through nucleotide 8 of SEQ ID NO:7 and the termination codon spans from nucleotide 822 through nucleotide 824 of SEQ ID NO:7. The coding region encoding PCfCBP<sub>272</sub>, is represented by nucleic acid molecule

nCfCBP<sub>816</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:10 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:12. The amino acid sequence of PCfCBP<sub>272</sub>, also represented as SEQ ID NO:11, predicts that PCfCBP<sub>272</sub> has an estimated molecular weight of about 30.6 kDa and an estimated pI of about 7.3.

Comparison of amino acid sequence SEQ ID NO:8 with amino acid sequences reported in GenBank indicates that SEQ ID NO:8 showed the most homology, i.e., about 26% identity with a *Lucilia cuprina* peritrophin-44 protein, GenBank Accession No. 407976. Comparison of SEQ ID NO:10 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:10 showed the most homology, i.e., about 40% with a *Lucilia cuprina* peritrophin-44 nucleic acid molecule, GenBank Accession number L25106. Percent identity calculations were performed using GCG version 9.0 using default parameters.

A nucleic acid molecule comprising nucleotides 59 through 827 of SEQ ID NO:7, encoding a predicted mature flea chitin-binding protein, was PCR amplified from the pBluescript™ clone described above as the template, using sense primer CBP-FE, having nucleotide sequence 5' **CGG GAT CCT** GCT GAC AGG AAT TCG CCC AC 3', having a *Bam*HI site indicated in bold, designated herein as SEQ ID NO:<sup>51</sup>(39), and anti-sense primer CBP-RE, having nucleotide sequence 5' CAT **GGT ACC** CCT GGT TTA AGC CTT ACT TAG C 3', having a *Kpn*I site indicated in bold, designated herein as SEQ ID NO:<sup>52</sup>(38). PCR reactions were performed using standard PCR reaction and thermocycling conditions described in Example 4. The PCR product was digested with *Bam*HI and

*Kpn*I and ligated into the vector pTrcHisB, available from Invitrogen, that had been digested with *Bam*HI and *Kpn*I and treated with alkaline phosphatase. The resulting recombinant molecule, referred to herein as pTrc-nCfCBP<sub>769</sub>, was transformed into *E. coli* strain BL21, available from Novagen, to form recombinant cell *E. coli*:pTrc-nCfCBP<sub>769</sub>.

- 5 The recombinant cell was grown under standard conditions and then incubated in the presence of 0.5  $\mu$ M IPTG to induce expression of recombinant protein, predicted to be a protein of approximately 32 kDa. Expression of protein was confirmed using Coomassie-blue-stained Tris-glycine gel and by Western blot using a T7 tag antibody which showed expression of an about 32-kDa protein. The protein product was purified by liquid
- 10 chromatography using a HiTrap™ chelating column charged with NiCl<sub>2</sub>, available from Pharmacia, and was shown to contain the His tag of the vector when subjected to automated protein sequencing by Edman degradation.

- Northern Blot analysis was conducted as described in Example 4 to determine whether CBP mRNA is expressed in only HMT tissue, only in certain stages of the flea
- 15 life cycle and whether CBP mRNA expression is influenced by feeding. Total RNA was extracted from flea tissues, life stages and feeding conditions as described in Example 4. Each RNA sample was separated by gel electrophoresis, transferred to a nylon membrane and hybridized with  $\alpha$ -<sup>32</sup>P-ATP labeled nCfCBP<sub>429</sub> under the Northern Blotting conditions described in Example 4. Analysis of the developed film revealed that CBP mRNA was
  - 20 expressed in HMT tissues but not in non-HMT tissues. CBP mRNA was also detected in all adult fleas tested regardless of feeding conditions but was not detected in any of the non-adult life stages.

Example 6

This example describes the cloning and sequencing of a *C. felis* sodium/potassium ATPase, beta subunit nucleic acid molecule.

A TA clone from the HMT EST library described in Example 1 was sequenced  
 5 using standard sequencing methods and shown to have homology to the nervous system antigen 1 gene from *Drosophila melanogaster*. This clone was digested with *Eco*RI to excise an insert about 439 nucleotides in length, referred to as flea NKB nucleic acid molecule nCfNKAB<sub>439</sub>. The insert was isolated by gel purification using a Gel Purification kit, available from Qiagen. Approximately 50 ng of purified nCfNKAB<sub>439</sub>  
 10 was used to construct a <sup>32</sup>P α-dATP labeled DNA probe using a Megaprime DNA labeling kit, available from Amersham, using the manufacturer's protocols.

The <sup>32</sup>P α-dATP labeled probe was used in a plaque lift hybridization procedure to isolate a clone from the HMT lambda-ZAP unsubtracted cDNA library described in Example 1, using standard hybridization conditions described in Example 4. Plaques that  
 15 hybridized strongly to the probe were isolated and subjected to *in vivo* excision. *In vivo* excision was performed using the Stratagene Ex-Assist™ helper phage system and protocols, to convert a positive plaque to pBluescript™ plasmid DNA, and sequencing was conducted following preparation of DNA with a Qiagen Qiaprep™ spin mini prep kit using the manufacturer's instructions and restriction enzyme digestion with about 1 μl of  
 20 20 U/μl each of *Eco*RI and *Xho*I, available from New England Biolabs. A clone was isolated from a secondary plaque, containing a nucleic acid molecule of about 1714 base pairs, referred to herein as nCfNKAB<sub>1714</sub>, having a nucleotide sequence denoted herein as



SEQ ID NO:13. The complement of SEQ ID NO:13 is represented herein as SEQ ID NO:15. Sequencing of nCfNKAB<sub>439</sub> indicates that nCfNKAB<sub>439</sub> shared 100% identity with nucleotides 907 through 1345 of SEQ ID NO:13.

Translation of SEQ ID NO:13 suggests that nucleic acid molecule nCfNKAB<sub>1714</sub> encodes a full-length NKAB protein of 326 amino acids, referred to herein as PCfNKAB<sub>326</sub>, having an amino acid sequence represented by SEQ ID NO:14, assuming the initiation codon spans from nucleotide 294 through nucleotide 296 of SEQ ID NO:13 and the termination codon spans from nucleotide 1272 through nucleotide 1274 of SEQ ID NO:13. The coding region encoding PCfNKAB<sub>326</sub> is represented by nucleic acid molecule nCfNKAB<sub>978</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:16 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:18. The amino acid sequence of PCfNKAB<sub>326</sub>, also represented by SEQ ID NO:17 predicts that PCfNKAB<sub>326</sub> has an estimated molecular weight of about 37.7 kDa and an estimated pI of about 5.

Comparison of amino acid sequence SEQ ID NO:14 with amino acid sequences reported in GenBank indicates that SEQ ID NO:14 showed the most homology, i.e., about 46% identity, with a *Drosophila melanogaster* nervous system antigen 2 protein, GenBank Accession No. 881344. Comparison of SEQ ID NO:16 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:16 showed the most homology, i.e., about 52% identity, with a *Drosophila melanogaster* nervous system antigen 2 nucleic acid molecule, GenBank Accession number U22440. Percent identity calculations were performed using GCG version 9.0 using default parameters.

Example 7

This example describes the cloning and sequencing of a *C. felis* ligand-gated ion channel nucleic acid molecule. This example also describes the expression of ligand-gated ion channel mRNA in a variety of flea tissues.

5        A TA clone from the HMT EST library described in Example 1 was sequenced using standard sequencing methods and shown to have homology to a human ligand-gated chloride channel nucleic acid molecule. The clone was digested with *Eco*RI to excise an insert about 376 nucleotides in length, referred to as flea LGIC nucleic acid molecule nCfLGIC<sub>376</sub>. The insert was isolated by gel purification using a Gel Purification  
10    kit, available from Qiagen. Approximately 50 ng of purified nCfLGIC<sub>376</sub> was used to construct a <sup>32</sup>P α-dATP labeled DNA probe using a Megaprime DNA labeling kit available from Amersham, using the manufacturer's protocols.

The <sup>32</sup>P α-dATP labeled probe was used in a plaque lift hybridization procedure to isolate a clone from the HMT lambda-ZAP unsubtracted cDNA library described in  
15    Example 1, using standard hybridization conditions described in Example 4. Plaques that hybridized strongly to the probe were isolated and subjected to *in vivo* excision. *In vivo* excision was performed using the Stratagene Ex-Assist™ helper phage system and protocols, to convert a positive plaque to pBluescript™ plasmid DNA and sequencing was conducted following preparation of DNA with a Qiagen Qiaprep™ spin mini prep kit  
20    using the manufacturer's instructions and restriction enzyme digestion with about 1 μl of 20 U/μl each of *Eco*RI and *Xho*I, available from New England Biolabs. A clone was isolated from a secondary plaque, containing a nucleic acid molecule of about 2240 base

pairs, referred to herein as n nCfLGIC<sub>2240</sub>, having a nucleotide sequence denoted herein as SEQ ID NO:19. The complement of SEQ ID NO:19 is represented herein as SEQ ID NO:21. Sequencing of nCfLGIC<sub>376</sub> indicates that nCfLGIC<sub>376</sub> shared 100% identity with nucleotides 763 through 1138 of SEQ ID NO:19.

- 5 Translation of SEQ ID NO:19 suggests that nucleic acid molecule nCfLGIC<sub>2240</sub> encodes a partial-length LGIC protein of 569 amino acids, referred to herein as PCfLGIC<sub>569</sub>, having an amino acid sequence represented by SEQ ID NO:20, assuming the initiation codon spans from nucleotide 1 through nucleotide 3 of SEQ ID NO:19 and the termination codon spans from nucleotide 1708 through nucleotide 1710 of SEQ ID
- 10 NO:19. The coding region encoding PCfLGIC<sub>569</sub>, is represented by nucleic acid molecule nCfLGIC<sub>1707</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:22 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:24. The amino acid sequence of PCfLGIC<sub>569</sub>, also represented as SEQ ID NO:23, predicts that PCfLGIC<sub>569</sub> has an estimated molecular weight of about 64 kDa and an
- 15 estimated pI of about 6.6.

- Comparison of amino acid sequence SEQ ID NO:20 with amino acid sequences reported in GenBank indicates that SEQ ID NO:20 showed the most homology, i.e., about 23% identity, with a *Rattus norvegicus* glycine receptor alpha-3 chain precursor protein, GenBank Accession No. 121580. Comparison of SEQ ID NO:22 with nucleic acid
- 20 sequences reported in GenBank indicates that SEQ ID NO:22 showed the most homology, i.e., about 38% identity, with a human glycine receptor alpha-3 subunit nucleic

acid molecule, GenBank Accession number AF017715. Percent identity calculations were performed using GCG version 9.0 using default parameters.

Northern Blot analysis was conducted as described in Example 4 to determine whether LGIC mRNA is expressed in only HMT tissue. Total RNA was extracted from HMT tissues and non-HMT tissues as described in Example 4. Each RNA sample was separated by gel electrophoresis, transferred to nylon membranes and hybridized with  $\alpha$ -<sup>32</sup>P-ATP labeled nCfLGIC<sub>376</sub> under the Northern Blotting conditions described in Example 4. Analysis of the developed film revealed that LGIC mRNA was expressed in HMT tissues but not in non-HMT tissues.

Additional nucleic acid sequence corresponding to the coding regions at the 5' end of the LGIC cDNA described above was isolated by PCR using the RACE cDNA pool prepared as described in Example 3 as the template. A first PCR reaction was conducted using reverse primer LGIC-R4, which is complementary to nucleotides 200-223 of SEQ ID NO:19, having a nucleic acid sequence 5' GCG ATA CTG GTG GTA CTG GTG AAG 3', denoted herein as SEQ ID NO:1932 was used with the forward linker primer Adapter Primer 1, having a nucleic acid sequence 5' CCA TCC TAA TAC GAC TCA CTA TAG GGC 3', denoted herein as SEQ ID NO:1933 using standard PCR reaction conditions and the following thermocycling conditions: (1) 94°C for 30 seconds, (2) 5 cycles of 94°C for 10 seconds then 72°C for 4 minutes, (3) 5 cycles of 94°C for 10 seconds then 70°C for 4 minutes, and (4) 25 cycles of 94°C for 10 seconds then 68°C for 4 minutes. The reaction product was separated on a 1.5% agarose gel and stained by ethidium bromide, but no clear bands were seen. The first PCR reaction product was diluted 1:50 in water and used as template for a second PCR reaction using reverse

primer LGIC-R5, which is complementary to nucleotides 88-110 of SEQ ID NO:19, having a nucleic acid sequence 5' GAG GTG GTT GTC TTC AGT GGT TG 3', denoted herein as SEQ ID NO:1934 and forward Adapter Primer 2, having a nucleic acid sequence 5' ACT CAC TAT AGG GCT CGA GCG GC 3', denoted herein as SEQ ID

5 NO:1935 under the same reaction conditions described for the first PCR reaction. The reaction product was separated by electrophoresis on a 1.5% agarose gel and stained with ethidium bromide revealing an approximately 700 bp band. This band was cut from the gel and purified using the QIAquick Gel Extraction Kit, then ligated into the pCR II TA Cloning vector, available from Invitrogen Corporation, Carlsbad, CA, using the

10 manufacture's protocol. This clone, referred to herein as nCfLGIC<sub>613</sub> and having a coding sequence denoted SEQ ID NO:1859, and a complementary strand denoted herein as SEQ ID NO:1860 was sequenced using an ABI PRISM 377 automatic DNA Sequencer, available from Perkin Elmer, Branchburg, NJ. Sequence analysis revealed that nucleotides 503-613 of nCfLGIC<sub>613</sub> had 100% identity with nucleotides 1-110 of SEQ ID

15 NO:19. The two sequences were aligned to form a 2739 nucleotide contiguous sequence, referred to herein as nCfLGIC<sub>2739</sub>, having a coding strand denoted herein as SEQ ID NO:1861 and a complementary strand denoted herein as SEQ ID NO:1863. Translation of SEQ ID NO:1861 suggests that nucleic acid molecule nCfLGIC<sub>2739</sub> encodes a full-length LGIC protein of 672 amino acids, referred to herein as PCfLGIC<sub>672</sub>, having an

20 amino acid sequence represented by SEQ ID NO:1862, assuming the initiation codon spans from nucleotide 191 through nucleotide 193 of SEQ ID NO:1861 and the termination codon spans from nucleotide 2207 through nucleotide 2209 of SEQ ID

NO:1861. The coding region encoding PCfLGIC<sub>672</sub>, is represented by nucleic acid molecule nCfLGIC<sub>2016</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:1864 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:1866. The amino acid sequence of PCfLGIC<sub>672</sub>, i.e. SEQ ID NO:1862, predicts that PCfLGIC<sub>672</sub> has an estimated molecular weight of about 75.5 kDa and an estimated pI of about 5.89.

Comparison of amino acid sequence SEQ ID NO:1862 with amino acid sequences reported in GenBank indicates that SEQ ID NO:1862 showed the most homology, i.e., 31.4% identity with glycine receptor Alpha 3 chain precursor cDNA from *Rattus norvegicus* (Accession # P24524). Comparison of SEQ ID NO:1864 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:1864 showed the most homology, i.e., about 43.1% identity with the *Homo sapiens* glycine receptor, alpha3 cDNA (Accession # NP006520). Percent identity calculations were performed using GCG version 9.0 using default parameters.

A LGIC nucleic acid molecule for recombinant expression of the predicted extracellular domain was produced as follows. In order to ligate the region encoding the predicted extracellular domain of the LGIC cDNA into the InsectSelect™ expression vector pIB/V5-His, two separate but overlapping DNA fragments were generated to be used as the template in the PCR overlap extension. To generate a 3' DNA fragment, a first PCR reaction was conducted using forward primer LGIC-ECD-D2F, which corresponds to nucleotides 2-25 of SEQ ID NO:19, having a nucleic acid sequence 5' CAA TTT TAA ACG CAT CCA CGA CCG 3', denoted herein as SEQ ID NO:1936, and

reverse primer LGIC-ECD-RE, which is complementary to nucleotides 937-961 of SEQ ID NO:19, having a nucleic acid sequence 5' CCG **CTC GAG** CGA CCC ATT TCA CGA CTT ATT TGA ATC G 3', denoted herein as SEQ ID NO:1937 and having a *Xho*I site indicated in bold, to amplify nucleotides 2-963 from SEQ ID NO:19 which was used as template under standard PCR reaction conditions and the following thermocycling conditions: (1) 94°C for 30 seconds, (2) 25 cycles of 94°C for 10 seconds, 55°C for 10 seconds, and 72°C for 3 minutes. The products of this reaction were separated on a 1.5% agarose gel, and a band corresponding to an approximately 960 nucleotide molecule was cut from the gel and purified using the QIAquick Gel Extraction Kit as described above.

To generate a 5' cDNA fragment, a second PCR reaction was conducted using reverse primer LGIC-R5 (SEQ ID NO:1934) and forward primer LGIC-ECD-FE, which corresponds to nucleotides 188-215 of SEQ ID NO:1859, having a nucleic acid sequence 5' **GGA ATT** CTA AAA TGC ACA ACA AAA TCC TGG TCC TGG 3', denoted herein as SEQ ID NO:1938, and having an *Eco*RI site indicated in bold, using SEQ ID NO:1859 as the template under the thermocycling conditions described for generating the 3' fragment. The products of this reaction were separated on a 1.5% agarose gel, and a band corresponding to an approximately 425 nucleotide molecule was cut from the gel and purified using the QIAquick Gel Extraction Kit as described above.

For the PCR overlap extension reaction, the 5' and 3' cDNA fragments described above were used as the template in a PCR reaction with forward primer LGIC-ECD-FE and reverse primer LGIC-ECD-RE under the thermocycling conditions described for generating the 5' and 3' fragments. The products of this reaction were separated on a 1.5% agarose gel, and a band corresponding to an approximately 1300 nucleotide

molecule, as visualized by agarose gel electrophoresis and ethidium bromide staining, referred to herein as nCfLGIC<sub>1300</sub>, was cut from the gel and purified using the QIAquick Gel Extraction Kit as described above.

The product of the PCR overlap extension reaction was the digested with *EcoRI* and *XhoI* restriction endonucleases, available from New England BioLabs, Inc., Beverly, MA, for 18 hours at 37 °. The digestion product was purified using the QIAquick Nucleotide Removal Kit, available from Qiagen, and ligated into the vector pIB/V5-His which had also been digested with *EcoRI* and *XhoI* and treated with shrimp alkaline phosphatase, available from New England BioLabs, Inc. for 30 minutes at 37 °.

Following standard transformation procedures, a bacterial clone containing the plasmid pIB/V5-His-nCfLGIC<sub>1300</sub> was isolated. DNA sequence analysis of pIB/V5-His-nCfLGIC<sub>1300</sub> confirmed that nucleotides 188-1464 of SEQ ID NO:1861 had been successfully ligated into the pIB/V5-His expression vector in frame with the C-terminal V5 epitope encoded by the vector.

#### 15 Example 8

This example describes the cloning and sequencing of a *C. felis* ANON/23DA nucleic acid molecule. This example also describes the expression of ANON/23DA mRNA in a variety of flea tissues.

A TA clone from the HMT EST library described in Example 1 was sequenced using standard sequencing methods and shown to have homology to an ANON/23DA gene from *Drosophila melanogaster*. This clone was digested with *EcoRI* to excise an insert about 177 nucleotides in length, referred to as flea ANON nucleic acid molecule



nCfANON<sub>177</sub>. The insert was isolated by gel purification using a Gel Purification kit, available from Qiagen. Approximately 50 ng of purified nCfANON<sub>177</sub> was used to construct a <sup>32</sup>P α-dATP labeled DNA probe using a Megaprime DNA labeling kit, available from Amersham, using the manufacturer's protocols.

5           The <sup>32</sup>P α-dATP labeled probe was used in a plaque lift hybridization procedure to isolate a clone from the HMT lambda-ZAP unsubtracted cDNA library described in Example 1, using standard hybridization conditions described in Example 4. Plaques that hybridized strongly to the probe were isolated and subjected to *in vivo* excision. *In vivo* excision was performed using the Stratagene Ex-Assist™ helper phage system and  
10       protocols, to convert a positive plaque to pBluescript™ plasmid DNA and sequencing of DNA was conducted following preparation with a Qiagen Qiaprep™ spin mini prep kit using the manufacturer's instructions and restriction enzyme digestion with about 1 μl of 20 U/μl each of *Eco*RI and *Xho*I, available from New England Biolabs. A clone was isolated from a secondary plaque, containing a nucleic acid molecule of about 1429 base  
15       pairs, referred to herein as nCfANON<sub>1429</sub>, having a nucleotide sequence denoted herein as SEQ ID NO:25. The complement of SEQ ID NO:25 is represented herein as SEQ ID NO:27. Sequencing of nCfANON<sub>177</sub> indicates that nCfANON<sub>177</sub> shared 100% identity with nucleotides 279 through 455 of SEQ ID NO:25.

Translation of SEQ ID NO:25 suggests that nucleic acid molecule nCfANON<sub>1429</sub>  
20       encodes a full-length ANON protein of 398 amino acids, referred to herein as PCfANON<sub>398</sub>, having an amino acid sequence represented by SEQ ID NO:26, assuming the initiation codon spans from nucleotide 18 through nucleotide 20 of SEQ ID NO:25

and the termination codon spans from nucleotide 1212 through nucleotide 1214 of SEQ ID NO:25. The coding region encoding PCfANON<sub>398</sub>, is represented by nucleic acid molecule nCfANON<sub>1194</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:28 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:30. The amino acid sequence of PCfANON<sub>398</sub>, also represented as SEQ ID NO:29, predicts that PCfANON<sub>398</sub> has an estimated molecular weight of about 45 kDa and an estimated pI of about 8.8.

Comparison of amino acid sequence SEQ ID NO:26 with amino acid sequences reported in GenBank indicates that SEQ ID NO:26 showed the most homology, i.e., about 65% identity, with a *Drosophila melanogaster* ANON/23DA protein, GenBank Accession No. 924937. Comparison of SEQ ID NO:28 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:28 showed the most homology, i.e., about 60% identity, with a *Drosophila melanogaster* ANON/23DA nucleic acid molecule, GenBank Accession number U29170. Percent identity calculations were performed using GCG version 9.0 using default parameters.

Northern Blot analysis was conducted as described in Example 4 to determine whether ANON mRNA is expressed in only HMT tissue, only in certain stages of the flea life cycle and whether ANON mRNA expression is influenced by feeding. Total RNA was extracted from flea tissues, life stages and feeding conditions as described in Example 4. Each RNA sample was separated by gel electrophoresis, transferred to nylon membranes and hybridized with  $\alpha$ -<sup>32</sup>P-ATP labeled nCfANON<sub>177</sub> under the Northern Blotting conditions described in Example 4. Analysis of the developed film revealed that

ANON mRNA was expressed in non-HMT tissues but not in HMT tissues. ANON mRNA was also detected in all adult fleas tested regardless of feeding conditions and in the wandering larvae and pupal life stages.

#### Example 9

5           This example describes the cloning and sequencing of a *C. felis* malvolio nucleic acid molecule.

A TA clone from the HMT EST library described in Example 1 was digested with *Eco*RI to excise an insert about 432 nucleotides in length, referred to as nCfMALV<sub>432</sub>. The insert was isolated by gel purification using a Gel Purification kit, available from  
10   Qiagen and sequenced using standard sequencing methods and shown to have homology to a malvolio gene from *Drosophila melanogaster*, hereinafter referred to as a flea MALV nucleic acid molecule.

Sequence information from nCfMALV<sub>432</sub> was used to design PCR primers to amplify a *C. felis* MALV nucleic acid molecule from the HMT unsubtracted library  
15   described in Example 1 using a nested PCR as follows. Sense primer MALV R1, having the nucleotide sequence 5' CCA TTA TTA ACC TGG TCG ACC AC 3', designated SEQ ID NO:41 and corresponding to nucleotides 365-387 of nCfMALV<sub>432</sub> and reverse primer M13 Reverse, having the nucleotide sequence 5' GGA AAC AGT ATG ACC ATG 3', designated SEQ ID NO:42 were used in a first PCR reaction using HMT unsubtracted  
20   library as the template using standard PCR reaction and thermocycling conditions, with the exception that 2 µl of template was used. The reaction product from the first PCR reaction was diluted 1:50 and used as the template in a second PCR reaction as follows.

Reverse primer malvolio R2, having a nucleotide sequence 5' CGC TAT AGT CGG TAG GGT CGC 3', designated SEQ ID NO:43 and corresponding to nucleotides 239-259 of nCfMALV<sub>432</sub> and forward primer T3, having a nucleotide sequence 5' AAT TAA CCC TCA CTA AAG GG 3' were used in a second PCR reaction under standard PCR reaction  
5 and thermocycling conditions.

The second PCR reaction resulted in an approximately 1000 bp PCR product which was separated by electrophoresis on a 1.5% agarose gel, excised and purified using a Gel Purification Kit, available from Qiagen. The purified PCR product was ligated into the pCRII™, Original TA cloning vector, available from Invitrogen. The ligation  
10 reaction was then used to transform INVαF' One Shot™ competent cells, available from Invitrogen, which were plated on LB agar with 50 micrograms per milliliter (μg/ml) ampicillin, available from Sigma-Aldrich Co., and 50 μg/ml X-Gal, available from Fisher Biotech. A clone was isolated from the ligation mix containing a nucleic acid molecule of about 765 base pairs, referred to herein as nCfMALV<sub>765</sub>, having a nucleotide sequence  
15 denoted herein as SEQ ID NO:31. The complement of SEQ ID NO:31 is represented herein as SEQ ID NO:33.

Translation of SEQ ID NO:31 suggests that nucleic acid molecule nCfMALV<sub>765</sub> encodes a partial-length MALV protein of 254 amino acids, referred to herein as PCfMALV<sub>254</sub>, having an amino acid sequence represented by SEQ ID NO:32, assuming  
20 the initiation codon spans from nucleotide 2 through nucleotide 4 of SEQ ID NO:31 and the last codon spans from nucleotide 761 through nucleotide 763 of SEQ ID NO:31. The coding region encoding PCfMALV<sub>254</sub>, is represented by nucleic acid molecule

nCfMALV<sub>762</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:34 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:36. The amino acid sequence of PCfMALV<sub>254</sub>, also represented as SEQ ID NO:35, predicts that PCfMALV<sub>254</sub> has an estimated molecular weight of about 36 kDa and an estimated pI of about 4.9.

Comparison of amino acid sequence SEQ ID NO:32 with amino acid sequences reported in GenBank indicates that SEQ ID NO:32 showed the most homology, i.e., about 71% identity, with a *Drosophila melanogaster* malvolio protein, GenBank Accession No. 780776. Comparison of SEQ ID NO:34 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:34 showed the most homology, i.e., about 63% identity, with a *Drosophila melanogaster* malvolio nucleic acid molecule, GenBank Accession number U23948. Percent identity calculations were performed using GCG version 9.0 using default parameters.

#### Example 10

This example describes the cloning, sequencing, and recombinant expression of a *C. felis* odorant-binding protein-like (OS-D) nucleic acid molecule. This example also describes the expression of OS-D mRNA in a variety of flea tissues.

A *C. felis* OS-D nucleic acid molecule of about 311 nucleotides was isolated from a cat blood-fed adult flea cDNA library, prepared as described in example 8 of PCT publication WO 96/11706 by Grieve et al., published April 25, 1996, by PCR amplification as follows. Sense primer 5'newBsaI5', having a nucleotide sequence 5' CAA AAC TGG TCT CCC CGC TC 3', denoted SEQ ID NO:57 was used in

combination with vector primer T7, having a nucleic acid sequence 5' TAA TAC GAC  
TCA CTA TAG GG 3', denoted SEQ ID NO:58, in a first PCR reaction using the cat  
blood-fed adult flea cDNA library as the template under standard PCR reaction and  
thermocycling conditions. A 311-nucleotide fragment, denoted nCfOSD<sub>311</sub> was isolated  
5 and shown to encode a partial length protein of 45 amino acids having a sequence similar  
to *Drosophila melanogaster* OS-D protein. Since primer 5'newBsaI5' was designed to be  
specific for the *C. felis* serpin constant region, nCfOSD<sub>311</sub> is believed to have been  
fortuitously amplified in this PCR reaction.

To isolate a flea OS-D nucleic acid molecule encoding a full-length OS-D protein,  
10 nucleic acid molecule nCfOSD<sub>311</sub> was used to design primers for a nested PCR as  
follows. Sense primer OSD-R1, having a nucleotide sequence 5' GGT TCG CCT CTC  
TTC ACT TG 3', which is complementary in sequence to nucleotides 108-127 of  
nCfOSD<sub>311</sub>, denoted SEQ ID NO:59, was used in combination with M13 reverse primer,  
SEQ ID NO:54, in a first PCR reaction using the cat blood-fed adult *C. felis* cDNA  
15 library as the template. The product of the first reaction was diluted 1:50 and used as the  
template for a second PCR reaction using reverse primer OSD-R2, having a nucleotide  
sequence 5' CGG TTG GAT CGT AAA CTG CAG 3', which is complementary in  
sequence to nucleotides 52-72 of nCfOSD<sub>311</sub>, denoted SEQ ID NO:60, and forward  
primer T3, SEQ ID NO:56. Each PCR reaction was conducted under standard PCR  
20 reaction and thermocycling conditions with the exception that an annealing temperature  
of 55°C was used rather than 50°C.

A DNA fragment of about 365 nucleotides, referred to herein as nCfOSD<sub>365</sub>, was isolated from the second PCR product and purified using a Gel Purification Kit, available from Qiagen. The purified fragment was ligated into the pCRII™ TA cloning vector, available from Invitrogen, and sequenced using standard sequencing methods.

- 5 Sequencing revealed that nucleotides 294-365 of nCfOSD<sub>365</sub> match nucleotides 1-72 of molecule nCfOSD<sub>311</sub> described above. The sequences from the partial length clones described were aligned to produce a sequence including a full-length coding region of 604 nucleotides, referred to as nCfOSD<sub>604</sub>, denoted herein as SEQ ID NO:37, where nCfOSD<sub>311</sub> is identical in sequence to nucleotides 294-604 of SEQ ID NO:37 and
- 10 nCfOSD<sub>365</sub> is identical in sequence to nucleotides 1-365 of SEQ ID NO:37. The complement of SEQ ID NO:37 is represented herein as SEQ ID NO:39.

- Translation of SEQ ID NO:37 suggests that nucleic acid molecule nCfOSD<sub>604</sub> encodes a full-length OS-D protein of 135 amino acids, referred to herein as PCfOSD<sub>135</sub>, having an amino acid sequence represented by SEQ ID NO:38, assuming the initiation
- 15 codon spans from nucleotide 26 through nucleotide 28 of SEQ ID NO:37 and the termination codon spans from nucleotide 431 through nucleotide 433 of SEQ ID NO:37. The coding region encoding PCfOSD<sub>135</sub>, is represented by nucleic acid molecule nCfOSD<sub>405</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:40 and a complementary strand with nucleic acid sequence represented by SEQ ID
- 20 NO:42. The amino acid sequence of PCfOSD<sub>135</sub>, also represented as SEQ ID NO:41, predicts that PCfOSD<sub>135</sub> has an estimated molecular weight of about 15 kDa and an estimated pI of about 8.6. Analysis of SEQ ID NO:38 suggests the presence of a signal

peptide encoded by a stretch of amino acids spanning from about amino acid 1 through about amino acid 20. The proposed mature protein, denoted herein as PCfOSD<sub>115</sub>, contains about 115 amino acids corresponding to amino acids 21 through 135 of SEQ ID NO:38. The predicted pI of the mature protein (i.e. the protein with the signal peptide removed) is 6.6.

Comparison of amino acid sequence SEQ ID NO:38 with amino acid sequences reported in GenBank indicates that SEQ ID NO:38 showed the most homology, i.e., about 60% identity, with a *Schistocerca gregaria* chemosensory protein CSP-sg4, GenBank Accession No. 3283938. Comparison of SEQ ID NO:40 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:40 showed the most homology, i.e., about 58% identity, with a *Schistocerca gregaria* chemosensory protein CSP-sg4 nucleic acid molecule, GenBank Accession number AF070964. Comparison of SEQ ID NO:40 with nucleic acid molecules sequenced when screening the HNC subtracted and unsubtracted libraries described in Example 2 revealed that OS-D (i.e. SEQ ID NO:40) is expressed in each of these libraries. Additional sequence analysis revealed that there are four cysteines present in *C. felis* OS-D which are conserved in sequence alignments with the four cysteines of OS-D-like molecules of other insects, including *D. melanogaster* OS-D protein GenBank Accession No. U02546, *S. gregaria* chemosensory protein CSP-sg4, GenBank Accession number AF070964, and cockroach leg regenerative protein, GenBank Accession No. AF030340. Percent identity calculations and additional sequence analysis was performed using GCG version 9.0 using default parameters.



A nucleic acid molecule comprising nucleotides 91 through 447 of SEQ ID  
 NO:37, encoding a predicted mature flea OS-D protein, was PCR amplified using the  
 pBluescript™ clone described above as the template, using sense primer OSD-FE, having  
 nucleotide sequence 5' CGC **GGA TCC** AGA AGA TAA ATA TAC TAG CAA ATT  
 5 TGA TAA C 3', having a *Bam*HI site indicated in bold, designated herein as SEQ ID  
 NO:61, and anti-sense primer OSD-RE, having nucleotide sequence 5' GAG **GAA TTC**  
 CTC TTT TTG GAA ATT TAA ACT GTA ACG G 3', having an *Eco*RI site indicated in  
 bold, designated herein as SEQ ID NO:62. PCR reactions were performed using standard  
 PCR reaction and thermocycling conditions described in Example 4; the product was  
 10 separated by agarose gel electrophoresis, and a fragment was excised and purified using a  
 Gel Purification Kit, available from Qiagen. The fragment was digested with *Bam*HI and  
*Eco*RI and ligated into the vector pTrcHisB, available from Invitrogen, that had been  
 digested with *Bam*HI and *Eco*RI and treated with alkaline phosphatase. The resulting  
 recombinant molecule, referred to herein as pTrc-nCfOSD<sub>357</sub>, was transformed into *E.*  
 15 *coli* strain BL21, available from Novagen, to form recombinant cell *E. coli*:pTrc-  
 nCfOSD<sub>357</sub>.

The recombinant cell was grown under standard conditions then incubated in the  
 presence of 0.5 mM IPTG to induce expression of recombinant protein, predicted to be  
 approximately 17-kDa. Expression of protein was confirmed using Coomassie-blue-  
 20 stained Tris-glycine gel and by Western blot using a T7 tag antibody which showed  
 expression of an about 17 kDa protein.

A Northern Blot analysis was conducted as follows to determine whether OS-D mRNA is expressed exclusively in HNC tissues. HNC tissues were dissected from 1500 adult cat blood-fed *C. felis* having a male to female ratio of 1:4. Total RNA was separately extracted from HNC tissues and the HNC-less carcasses that resulted from these dissections using a standard guanidine lysis method, described by Sambrook et al., *ibid.*

Approximately 15 µg of each RNA were separated by electrophoresis on either Glyoxal gels with RNA prepared according to Burnett, Biotechniques, 22:4, pp. 668-671, 1997, or formaldehyde gels with RNA prepared according to Sambrook et al., *ibid.*

Following electrophoresis, RNA was blotted to Hybond N nylon membranes, available from Amersham, according to the protocols described in Burnett and Sambrook et al. *ibid.* The membrane was UV cross-linked using the Stratalinker®, available from Stratagene, and placed in approximately 30 ml of hybridization buffer consisting of 5X SSPE, 1% Sarcosyl, 50% formamide, 5X Denhardt's reagent and 25 mM EDTA at 42°C for approximately 3 to 6 hours. A probe comprising the flea OS-D nucleic acid molecule nCfOSD<sub>357</sub> was labeled with  $\alpha$ -<sup>32</sup>P-ATP using a DNA labeling kit, available from Amersham and added to the buffer at a concentration of approximately 1 x 10<sup>6</sup> cpm/ml, and allowed to hybridize for about 14 to 18 hours at 42°C. The blot was then washed twice for 10 minutes per wash in 0.5X SSPE and 0.1% sarcosyl at 55°C and exposed to film for autoradiography. Analysis of the developed film showed that there was greater expression of OS-D mRNA in HNC tissues compared to non-HNC tissues, indicating possible upregulation of OS-D in flea head and nerve cords.

Example 11

This example describes the cloning and sequencing of a *C. felis* N-methyl-D-aspartate receptor associated (NMDA) nucleic acid molecule.

A TA clone from the HMT EST library described in Example 1 was sequenced  
5 using standard sequencing methods and shown to have significant homology to NMDA  
genes. This clone was digested with *Eco*RI to excise an insert 279 nucleotides in length,  
referred to as flea NMDA nucleic acid molecule nCfNMDA<sub>279</sub>. The insert was isolated  
by gel purification using a Gel Purification kit, available from Qiagen. Approximately 50  
ng of purified nCfNMDA<sub>279</sub> was used to construct a <sup>32</sup>P α-dATP labeled DNA probe  
10 using a Megaprime DNA labeling kit, available from Amersham, using the  
manufacturer's protocols.

The <sup>32</sup>P α-dATP labeled probe was used in a plaque lift hybridization procedure to  
isolate a clone from the HMT lambda-ZAP unsubtracted cDNA library described in  
Example 1, using standard hybridization conditions described in Example 4. Plaques that  
15 hybridized strongly to the probe were isolated and subjected to *in vivo* excision. *In vivo*  
excision was performed using the Stratagene Ex-Assist™ helper phage system and  
protocols, to convert a positive plaque to pBluescript™ plasmid DNA and sequencing  
was conducted following preparation of DNA with a Qiagen Qiaprep™ spin mini prep kit  
using the manufacturer's instructions and restriction enzyme digestion with about 1 μl of  
20 20 U/μl each of *Eco*RI and *Xho*I, available from New England Biolabs. A clone was  
isolated from a secondary plaque, containing a nucleic acid molecule of about 1227 base  
pairs, referred to herein as nCfNMDA<sub>1227</sub>, having a nucleotide sequence denoted herein as

SEQ ID NO:43. The complement of SEQ ID NO:43 is represented herein as SEQ ID NO:45. Sequencing of nCfNMDA<sub>279</sub> indicates that nCfNMDA<sub>279</sub> shared 100% identity with nucleotides 709 through 987 of SEQ ID NO:43.

Translation of SEQ ID NO:43 suggests that nucleic acid molecule nCfNMDA<sub>1227</sub> encodes a full-length NMDA protein of 246 amino acids, referred to herein as PCfNMDA<sub>246</sub>, having an amino acid sequence represented by SEQ ID NO:44, assuming the initiation codon spans from nucleotide 312 through nucleotide 314 of SEQ ID NO:43 and the termination codon spans from nucleotide 1050 through nucleotide 1052 of SEQ ID NO:43. The coding region encoding PCfNMDA<sub>246</sub>, is represented by nucleic acid molecule nCfNMDA<sub>738</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:46 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:48. The amino acid sequence of PCfNMDA<sub>246</sub>, also represented as SEQ ID NO:47 predicts that PCfNMDA<sub>246</sub> has an estimated molecular weight of about 27 kDa and an estimated pI of about 5.6.

Comparison of amino acid sequence SEQ ID NO:44 with amino acid sequences reported in GenBank indicates that SEQ ID NO:44 showed the most homology, i.e., about 34% identity, with a *Emericella nidulans* negative-acting regulatory protein, GenBank Accession No. 3676056. Comparison of SEQ ID NO:46 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:46 showed the most homology, i.e., about 45% identity, with a *Drosophila melanogaster* NMDA nucleic acid molecule, GenBank Accession number L37377. Percent identity calculations were performed using GCG version 9.0 using default parameters.

Example 12

This example describes the cloning and sequencing of *C. felis* chemical sense related lipophilic ligand binding protein nucleic acid molecule. This example also describes the expression of chemical sense related lipophilic ligand binding protein mRNA in a variety of flea tissues.

A TA clone from the HNC EST library described in Example 2 was sequenced using standard sequencing methods and shown to have significant homology to chemical sense related lipophilic ligand binding protein (CLBP) genes. This clone was digested with *EcoRI* to excise an insert 339 nucleotides in length, referred to as flea CLBP nucleic acid molecule nCfCLBP<sub>339</sub>. The insert was isolated by gel purification using a Gel Purification kit, available from Qiagen, Chatsworth, CA. Approximately 50 ng of purified nCfCLBP<sub>339</sub> was used to construct a <sup>32</sup>P α-dATP labeled DNA probe using a Megaprime DNA labeling kit, available from Amersham, using the manufacturer's protocols.

The <sup>32</sup>P α-dATP labeled probe was used in a standard plaque lift hybridization procedure to isolate a clone from the HNC lambda-ZAP unsubtracted cDNA library described in Example 2. The following hybridization conditions were used. Filters were hybridized with about 5 X 10<sup>7</sup> counts per minute (cpm) per ml of the probe in 100 ml of buffer (5X SSPE, 1 % Sarcosyl, 0.1 mg/ml BLOTTO) at 45°C for about 14 hours. The filters were washed twice for 20 minutes per wash in 500 ml of 0.5X SSPE and 0.1% Sarcosyl at 55°C and subjected to autoradiography. Two plaques that hybridized strongly to the probe were isolated and subjected to *in vivo* excision using the Stratagene

Ex-Assist™ helper phage system and protocols. Miniprep DNA was prepared from each positive clone using a Quantum Prep mini prep kit, available from BioRad, Hercules, CA, and sequenced using standard sequencing procedures. Sequencing revealed that the two positive clones share 97% amino acid identity to each other. The first clone contained a

5 nucleic acid molecule of about 633 nucleotides, referred to herein as nCfCLBP1A<sub>633</sub>, having a nucleotide sequence denoted herein as SEQ ID NO:153. The complement of SEQ ID NO:153 is represented herein as SEQ ID NO:155. The second clone contained a nucleic acid molecule of about 631 nucleotides, referred to herein as nCfCLBP2A<sub>631</sub>, having a nucleotide sequence denoted herein as SEQ ID NO:162. The complement of

10 SEQ ID NO:162 is represented herein as SEQ ID NO:164. Sequencing of nCfCLBP<sub>340</sub> indicated that nCfCLBP<sub>339</sub> shared 100% identity with nucleotides 1 through 339 of SEQ ID NO:153 and shared 100% identity with nucleotides 2 through 339 of SEQ ID NO:162.

Translation of SEQ ID NO:153 suggests that nucleic acid molecule nCfCLBP1A<sub>633</sub> encodes a full-length CLBP protein of 147 amino acids, referred to herein

15 as PCfCLBP1A<sub>147</sub>, having an amino acid sequence represented by SEQ ID NO:154, assuming the initiation codon spans from nucleotide 67 through nucleotide 69 of SEQ ID NO:153 and the termination codon spans from nucleotide 511 through nucleotide 513 of SEQ ID NO:153. The coding region encoding PCfCLBP1A<sub>147</sub>, is represented by nucleic acid molecule nCfCLBP1A<sub>441</sub>, having a coding strand with the nucleic acid sequence

20 represented by SEQ ID NO:156 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:158. The amino acid sequence of PCfCLBP1A<sub>147</sub>, also

represented by SEQ ID NO:157, predicts that PCfCLBP1A<sub>147</sub> has an estimated molecular weight of about 15 kDa and an estimated pI of about 5.

Analysis of SEQ ID NO:154 suggests the presence of a signal peptide encoded by a stretch of amino acids spanning from about amino acid 1 through about amino acid 19.

- 5 The proposed mature protein, denoted herein as PCfCLBP1A<sub>128</sub>, contains 128 amino acids which is represented herein as SEQ ID NO:160. PCfCLBP1A<sub>128</sub> is encoded by a nucleic acid molecule denoted nCfCLBP1A<sub>384</sub> having a coding strand with nucleic acid sequence SEQ ID NO:159 and a complementary strand with SEQ ID NO:161.

- Translation of SEQ ID NO:162 suggests that nucleic acid molecule
- 10 nCfCLBP2A<sub>631</sub> encodes a full-length CLBP protein of 147 amino acids, referred to herein as PCfCLBP2A<sub>147</sub>, having an amino acid sequence represented by SEQ ID NO:163, assuming the initiation codon spans from nucleotide 65 through nucleotide 67 of SEQ ID NO:162 and the termination codon spans from nucleotide 509 through nucleotide 511 of SEQ ID NO:162. The coding region encoding PCfCLBP2A<sub>147</sub>, is represented by nucleic
- 15 acid molecule nCfCLBP2A<sub>441</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:165 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:167. The amino acid sequence of PCfCLBP2A<sub>147</sub> predicts that PCfCLBP2A<sub>147</sub> has an estimated molecular weight of about 15 kDa and an estimated pI of about 5.

- 20 Analysis of SEQ ID NO:163 suggests the presence of a signal peptide encoded by a stretch of amino acids spanning from about amino acid 1 through about amino acid 19. The proposed mature protein, denoted herein as PCfCLBP2A<sub>128</sub>, contains about 128

amino acids which is represented herein as SEQ ID NO:169. PCfCLBP2A<sub>128</sub> is encoded by a nucleic acid molecule denoted nCfCLBP2A<sub>384</sub> having a coding strand with nucleic acid sequence SEQ ID NO:168 and a complementary strand with SEQ ID NO:170.

Comparison of amino acid sequences SEQ ID NO:154 and SEQ ID NO:163 with  
 5 amino acid sequences reported in GenBank indicates that each sequence showed the most homology, i.e., about 29% identity, with a *Drosophila melanogaster* pheromone binding protein related protein 2 (PBPRP-2), GenBank Accession No. 1709595. Percent identity calculations were performed using GCG version 9.0 using default parameters. Blast  
 comparison of nucleic acid sequences SEQ ID NO:156 and SEQ ID NO:165 with nucleic  
 10 acid sequences reported in GenBank indicates that each sequence showed the most homology to a human Xp22 PAC PRC11-5G11 nucleic acid molecule, GenBank Accession number AC002369. Pairwise identity could not be performed as the human clone in GenBank is too large to load into GCG version 9.0. Blast comparison performed using default parameters showed an insignificant level of identity of 0.87. Additional  
 15 sequence analysis revealed that there are six cysteines present in *C. felis* CLBP which are conserved in sequence alignments with the six cysteines of neuronal/sense-related molecules in the PBP/GOBP family, including *D. melanogaster* PBPRP-2, GenBank Accession No. 1709595, and PBPRP-5, GenBank Accession No. P54195, proteins, and *Phormia regina* chemical sense related lipophilic ligand binding protein (CSRLBP),  
 20 GenBank Accession No. S65458.



A Northern Blot analysis was conducted to determine whether CLBP mRNA is expressed exclusively in HNC tissues. HNC tissues were dissected, total RNA was isolated and separated by electrophoresis as described in Example 10.

Following electrophoresis, RNA was blotted as described in Example 10 and a probe comprising clone nCfCLBP<sub>340</sub> labeled with  $\alpha$ -<sup>32</sup>P-ATP was added to the buffer at a concentration of approximately  $1 \times 10^6$  cpm/ml and allowed to hybridize for about 14 to 18 hours. The blot was then washed as described in Example 10 and exposed to film for autoradiography. Analysis of the developed film showed that there was greater expression of CLBP mRNA in HNC tissues compared to non-HNC tissues, indicating possible upregulation of CLBP in flea head and nerve cords.

The coding region of nCfCLBP2A<sub>631</sub>, i.e. SEQ ID NO:162, was PCR amplified from the pBluescript™ clone described above as the template, using sense primer 2A1BamSen having nucleotide sequence 5' ATG **GAT CCG** GCA AAA TAT ACC AAA GAA GAA G 3', having a *Bam*HI site indicated in bold, designated herein as SEQ ID NO:1952, and anti-sense primer 2A1antiR1, having nucleotide sequence 5' ATG **AAT TCT** TAT ATT GGT ATC GCG TCC ATT 3', having a *Eco*RI site indicated in bold, designated herein as SEQ ID NO:1953. PCR reactions were performed using the following thermocycling conditions: (a) one cycle at 95°C for one minute; (b) five cycles at 94°C for ten seconds, 49°C for twenty-five seconds, and 69°C for one minute; and (c) twenty-three cycles at 94°C for ten seconds, 53°C for twenty seconds, and 69°C for seventy-five seconds, in reactions containing 0.2 mM dNTPs, 1  $\mu$ M of each primer, 0.5  $\mu$ l of 5U/ $\mu$ l *KlenTaq* Advantage polymerase, available from Clontech, 1  $\mu$ l of 1  $\mu$ g/ $\mu$ l

template, and 1X *KlenTaq* buffer, hereinafter referred to as “standard PCR conditions”.

The PCR product was digested with *Bam*HI and *Eco*RI and ligated into the vector pTrcHisB, available from Invitrogen, that had been digested with *Bam*HI and *Eco*RI. The resulting recombinant molecule, referred to herein as pTrc- nCfCLBP2A<sub>441</sub>, was

- 5 transformed into *E. coli* strain BL21, available from Novagen Inc., Madison, WI, to form recombinant cell *E. coli*:pTrc- nCfCLBP2A<sub>441</sub>.

- 10 The recombinant cell was grown under standard conditions and then incubated in the presence of 0.5  $\mu$ M isopropylthio- $\beta$ -galactoside (IPTG) to induce expression of recombinant protein. Expression was confirmed using Coomassie-blue-stained Tris-glycine gel and by Western blot using a T7 tag antibody, available from Novagen, which showed expression of an about 18 kDa protein. The protein product was purified as follows. The recombinant cells were collected by centrifugation, the supernatant was discarded and the pellets were resuspended and homogenized in 60ml (total) of 50mM Tris pH8.0 containing 50mM NaCl and 1mM phenylmethylsulfonyl fluoride(PMSF).
- 15 The sample was then passed through the microfluidizer five times, rocked at 4°C for 20 minutes, and centrifuged at 20,000 x G for 30minutes. The supernatant was collected and filtered through a 0.45um filter then run over a HiTrap Chelating column, available from Amersham Pharmacia, in 50mM Tris pH8 containing 50mM NaCl and 10mM imidazole and eluted with an increasing imidazole gradient. The recombinant protein
- 20 was eluted at approximately 150mM imidazole. Fractions containing recombinant protein were pooled and concentrated using a Centricon Plus-20 (Amicon), and diafiltered into PBS. Quantification of the protein was performed by densitometry against a known standard.

Example 13

This Example describes the further characterization and expression of a Sodium/Hydrogen Transporter-like cDNA isolated by EST sequencing described in Example 1.

5 A cDNA designated clone 2231-94 was isolated from the unsubtracted HMT library as described in Example 1. Analysis of clone 2231-94 indicated that the cDNA, denoted nCfNAH<sub>2080</sub>, is about 2080 nucleotides in length, having a coding strand with nucleic acid sequence SEQ ID NO:1867 and a complementary sequence having SEQ ID NO:1869. Translation of SEQ ID NO:1867 suggests that nucleic acid molecule

10 nCfNAH<sub>2080</sub> encodes a full-length Sodium/Hydrogen Transporter-like protein of 608 amino acids, referred to herein as PCfNAH<sub>608</sub>, having an amino acid sequence represented by SEQ ID NO:1868, assuming the initiation codon spans from nucleotide 45 through nucleotide 47 of SEQ ID NO:1867 and the termination codon spans from nucleotide 1869 through nucleotide 1871 of SEQ ID NO:1867. The coding region encoding PCfNAH<sub>608</sub>,

15 is represented by nucleic acid molecule nCfNAH<sub>1824</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:1870 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:1871. The amino acid sequence of SEQ ID NO:1868, predicts that PCfNAH<sub>608</sub> has an estimated molecular weight of about 67.9 kDa and an estimated isoelectric point (pI) of about 6.47.

20 Comparison of amino acid sequence SEQ ID NO:1868 with amino acid sequences reported in GenBank indicates that SEQ ID NO:1868 showed the most homology, i.e., about 67.7% identity, with a sodium hydrogen exchanger NHE1 (Accession #

AAD32689.1). Comparison of SEQ ID NO:1867 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:1867 showed the most homology, i.e., about 59.5% identity, with a *Drosophila melanogaster* sodium hydrogen exchanger NHE1 (Accession # AF142676). Percent identity calculations were performed using GCG version 9.0 using  
 5 default parameters.

In order to express the full-length putative NaH protein, the entire coding region was amplified by PCR and then ligated into the InsectSelect™ expression vector pIB/V5-His, available from Invitrogen, as follows. Forward primer NaH-IS-FE, which corresponds to nucleotides 42-74 of SEQ ID NO:1867, having the sequence 5' GAC  
 10 **TAG TAA AAT GGG CGT TAA AAA TAT ATA TTT ATA CTG C** 3', denoted SEQ ID NO:1939 and having a *SpeI* site indicated in bold, was used in conjunction with reverse primer NaH-IS-RE, which is complementary to nucleotides 1845-1867 of SEQ ID NO:1867, having the sequence 5' CCG **CTC GAG GTA CTG CAC GTA CTA ACG**  
 15 **TCA TC** 3', denoted SEQ ID NO:1940 and having a *XhoI* restriction site indicated in bold, in a PCR reaction using SEQ ID NO:1867 as the template. Standard PCR reaction conditions were used with the following thermocycling conditions: (1) 94°C for 30 seconds, (2) 25 cycles of 94°C for 10 seconds, 55°C for 10 seconds and 72°C for 3 minutes. The products of this reaction were separated on a 1.5% agarose gel, and a band corresponding to an approximately 1825 nucleotide molecule was cut from the gel and  
 20 purified using the QIAquick Gel Extraction Kit as described above. The PCR product was then digested with *SpeI* and *XhoI* restriction endonucleases for 18 hours at 37°. The digestion product was purified using the QIAquick Nucleotide Removal Kit, available

from Qiagen, and ligated into the vector pIB/V5-His which had also been digested with *SpeI* and *XhoI* and treated with shrimp alkaline phosphatase, available from New England BioLabs, Inc., for 30 minutes at 37°. Following standard transformation procedures, a bacterial clone containing the plasmid pIB/V5-His-NaH was isolated. DNA sequence analysis of the clone confirmed that nucleotides 42-1867 of SEQ ID NO:1867, referred to herein as nCfNAH<sub>1826</sub>, had been successfully ligated into the pIB/V5-His expression vector in frame with the C-terminal V5 epitope encoded by the vector.

A Northern Blot analysis was conducted as described in Example 4 to determine whether NaH mRNA is expressed only in certain life stages of the flea life cycle and whether NaH mRNA is expressed only in HMT tissue. Total RNA was extracted from eggs, first, third, and wandering larvae, pupae, unfed adults, and adults fed on cat blood for 0.25, 2, 8, and 24 hours. In addition, total RNA was extracted from hindguts and Malpighian tubules extracted from 24 hour cat blood-fed adult fleas, and from the remaining body parts following the removal of hindguts and Malpighian tubules. Each RNA sample was separated by gel electrophoresis, transferred to nylon membranes and hybridized with  $\alpha$ -<sup>32</sup>P-ATP labeled nCfNAH<sub>1826</sub> under the Northern Blotting conditions described in Example 4. Analysis of the developed film revealed that NAH mRNA was expressed in the 0.25, 2, and 8 hour adult fed timepoints only.

#### Example 14

This Example describes the further characterization of a Chloride Intracellular Channel-like cDNA isolated by EST sequencing described in Example 1.

A cDNA designated clone 2233-24 was isolated from the unsubtracted HMT library as described in Example 1. Analysis of clone 2233-24 indicated that the cDNA, denoted nCfCLIC<sub>2283</sub> is about 2283 nucleotides in length, having a coding strand with nucleic acid sequence SEQ ID NO:1872 and a complementary sequence having SEQ ID

5 NO:1874. Translation of SEQ ID NO:1872 suggests that nucleic acid molecule nCfCLIC<sub>2283</sub> encodes a full-length Chloride Intracellular Channel-like protein of 262 amino acids, referred to herein as PCfCLIC<sub>262</sub>, having an amino acid sequence represented by SEQ ID NO:1873, assuming the initiation codon spans from nucleotide 60 through nucleotide 62 of SEQ ID NO:1872 and the termination codon spans from

10 nucleotide 846 through nucleotide 848 of SEQ ID NO:1872. The coding region encoding PCfCLIC<sub>262</sub>, is represented by nucleic acid molecule nCfCLIC<sub>786</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:1875 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:1876. The amino acid sequence of SEQ ID NO:1873, predicts that PCfCLIC<sub>262</sub> has an estimated molecular

15 weight of about 30.2 kDa and an estimated isoelectric point (pI) of about 6.02.

Comparison of amino acid sequence SEQ ID NO:1873 with amino acid sequences reported in GenBank indicates that SEQ ID NO:1873 showed the most homology, i.e., about 37.8% identity, with a *Homo sapiens* chloride intracellular channel 2 (Accession # NP001280.1). Comparison of SEQ ID NO:1872 with nucleic acid sequences reported in

20 GenBank indicates that SEQ ID NO:1872 showed the most homology, i.e., about 37.5% identity with a *Homo sapiens* chloride intracellular channel 2 (Accession # NM001289).

Percent identity calculations were performed using GCG version 9.0 using default parameters.

### Example 15

This Example describes the further characterization of a Peritrophin-like cDNA, referred to herein as PL2, isolated by EST sequencing described in Example 1.

A cDNA designated clone 2232-23 was isolated from the unsubtracted HMT library as described in Example 1, denoted herein as SEQ ID NO:1877. Analysis of clone 2232-23 indicated that the cDNA, denoted nCfPL2<sub>457</sub> is about 457 nucleotides in length. Translation of the coding strand of nCfPL2<sub>457</sub> suggests that nucleic acid molecule nCfPL2<sub>457</sub> encodes a partial-length Peritrophin-like protein of 113 amino acids, referred to herein as PCfPL2<sub>113</sub>, assuming a stop coding at nucleotides 342-344 of nCfPL2<sub>457</sub>.

Additional coding sequence corresponding to the 5' end of nCfPL2<sub>457</sub> was isolated by PCR performed using a RACE cDNA pool prepared as described in Example 3 as template. A first PCR reaction was performed using reverse primer PL2-R1, which is complementary to nucleotides 167-187 of the nCfPL2<sub>457</sub> cDNA, having a nucleic acid sequence 5' GTC TGG AAG CTC AGG AAG AGG 3', denoted herein as SEQ ID NO:1941, in conjunction with forward Adapter Primer 1, SEQ ID NO:1933, described above under the following thermocycling conditions: (1) 94°C for 30 seconds, (2) 5 cycles of 94°C for 10 seconds and 72°C for 4 minutes, (3) 5 cycles of 94°C for 10 seconds and 70°C for 4 minutes, and (4) 25 cycles of 94°C for 10 seconds then 68°C for 4 minutes. The product of this reaction was diluted 1:50 and used as template for a second PCR reaction as follows. Forward adapter primer 2, SEQ ID NO:1935, was used with reverse primer PL2-R2, which is complementary to nucleotides 29-52 of the

nCfPL2<sub>457</sub> cDNA, having a nucleic acid sequence 5' GTA ATA TGC GTG ACA ATC GTG TGG 3', denoted herein as SEQ ID NO:1942, using the thermocycling conditions described for the first PCR reaction. The resulting product was gel purified as described above to reveal a distinct band corresponding to nucleic acid molecule of approximately 5 900 bp in length. The fragment was then ligated into the pCR II TA Cloning vector, available from Qiagen and sequenced using an ABI PRISM 377 automatic DNA Sequencer. Sequencing revealed that nucleotides 791-835 of the fragment had 100% identity with nucleotides 1-45 of the nCfPL2<sub>457</sub> cDNA. The two sequences were aligned to form a contiguous sequence, denoted nCfPL2<sub>1291</sub>, which is about 1291 nucleotides in 10 length, having a coding strand with nucleic acid sequence SEQ ID NO:1878 and a complementary sequence having SEQ ID NO:1879. Translation of SEQ ID NO:1878 suggests that nucleic acid molecule nCfPL2<sub>1291</sub> encodes a non full-length Peritrophin-like protein of 391 amino acids.

In order to isolate the additional sequence corresponding to the 5' end of SEQ ID 15 NO:1878, nested PCR reactions were performed using the RACE cDNA pool as template. For the first PCR, forward adapter primer AP1 was used with reverse primer PL2-R1 under standard PCR reaction conditions and the following thermocycling conditions: (1) 94 °C for 1 minute, (2) 5 cycles of 94 °C for 20 seconds and 70 °C for 1 minute, (3) 5 cycles of 94 °C for 20 seconds and 68 °C for 1 minute, (4) 10 cycles of 20 94 °C for 20 seconds and 66 °C for 1 minute. The products of this reaction were diluted 1:50 in water and used as template for the second, nested PCR. The second PCR reaction used forward adapter primer AP2 in conjunction with reverse primer PL2-R5, which is



complementary to nucleotides 70-93 of SEQ ID NO:1878, having a nucleotide sequence 5' CGG TGC AAG TTA TAG AAC CTT CCG 3', denoted herein as SEQ ID NO:1943 under standard PCR reaction conditions using the following thermocycling conditions: (1) 94 °C for 1 minute, (2) 5 cycles of 94 °C for 20 seconds and 70 °C for 1 minute, (3) 5 cycles of 94 °C for 20 seconds and 68 °C for 1 minute, (4) 40 cycles of 94 °C for 20 seconds and 66 °C for 1 minute. The products of this reaction were separated by agarose gel electrophoresis and a band approximately 279 nucleotides in length was excised from the gel and purified as described above. The fragment, referred to as nCfPL2<sub>279</sub>, having a coding nucleic acid sequence designated SEQ ID NO:1880 and a complementary sequence designated SEQ ID NO:1881, was then ligated into the pCROII TA Cloning vector, available from Qiagen, and sequenced as described above. Sequencing revealed that nucleotides 228-279 of nCfPL2<sub>279</sub> were identical to nucleotides 42-93 of SEQ ID NO:1878, however, nucleotides 186-228 of nCfPL2<sub>279</sub> had no significant similarity to SEQ ID NO:1878. This discrepancy may be the result of alternative RNA splicing or may be an artifact of the cDNA pool. To determine the reason for this discrepancy, additional fragments corresponding to this region were isolated by PCR from flea cDNA libraries from adult midguts, hindgut and Malpighian tubules and mixed instar larvae using techniques described herein. Sequence analysis of fragments obtained from these libraries revealed that these fragments were identical in sequence to the sequence of nCfPL2<sub>279</sub>, therefore, the region of SEQ ID NO:1878 which did not align to nCfPL2<sub>279</sub> was deemed to be an artifact and was not used in subsequent alignments.

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The PL2 sequences described above were aligned to form a contiguous sequence, denoted nCfPL2<sub>1477</sub>, which is about 1477 nucleotides in length, having a coding strand with nucleic acid sequence SEQ ID NO:1882 and a complementary sequence having SEQ ID NO:1884. Translation of SEQ ID NO:1882 suggests that nucleic acid molecule

5 nCfPL2<sub>1477</sub> encodes a full-length Peritrophin-like protein of 453 amino acids, referred to herein as PCfPL2<sub>453</sub>, having an amino acid sequence represented by SEQ ID NO:1883, assuming an initiation codon spanning from nucleotide 3 through nucleotide 5 of SEQ ID NO:1882 and a termination codon spanning from nucleotide 1362 through nucleotide 1364 of SEQ ID NO:1882. The coding region encoding PCfPL2<sub>453</sub>, is represented by

10 nucleic acid molecule nCfPL2<sub>1359</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:1885 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:1886. The amino acid sequence of SEQ ID NO:1883, predicts that PCfPL2<sub>453</sub> has an estimated molecular weight of about 49 kDa and an estimated isoelectric point (pI) of about 4.7.

15 Comparison of amino acid sequence SEQ ID NO:1883 with amino acid sequences reported in GenBank indicates that SEQ ID NO:1883 showed the most homology, i.e., about 28% identity, with a *Drosophila melanogaster* locus AE003474 protein (Accession # AAF47629). Comparison of SEQ ID NO:1882 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:1882 showed the most homology, i.e., about 50%

20 identity, *Penaeus semisulcatus* (a crustacean) peritrophin-like protein 1 cDNA (Accession # AF095580). Percent identity calculations were performed using GCG version 9.0 using default parameters.

Example 16

This Example describes the further characterization and expression of a Peritrophin-like sequence cDNA, referred to herein as PL3, isolated by EST sequencing described in Example 1.

5 A cDNA designated clone 2240-17 was isolated from the unsubtracted HMT library as described in Example 1. Analysis of clone 2240-17 indicated that the cDNA, denoted nCfPL3<sub>406</sub>, is about 406 nucleotides in length, having a coding strand with nucleic acid sequence SEQ ID NO:1887 and a complementary sequence having SEQ ID NO:1889. Translation of SEQ ID NO:1887 suggests that nucleic acid molecule

10 nCfPL3<sub>406</sub> encodes a full-length Peritrophin-like protein of 81 amino acids, referred to herein as PCfPL3<sub>81</sub>, having an amino acid sequence represented by SEQ ID NO:1888, assuming the initiation codon spans from nucleotide 20 through nucleotide 22 of SEQ ID NO:1887 and the termination codon spans from nucleotide 263 through nucleotide 265 of SEQ ID NO:1887. The coding region encoding PCfPL3<sub>81</sub>, is represented by nucleic acid

15 molecule nCfPL3<sub>243</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:1890 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:1891. The amino acid sequence of SEQ ID NO:1888, predicts that PCfPL3<sub>81</sub> has an estimated molecular weight of about 9.1 kDa and an estimated isoelectric point (pI) of about 3.64.

20 Comparison of amino acid sequence SEQ ID NO:1888 with amino acid sequences reported in GenBank indicates that SEQ ID NO:1888 showed the most homology, i.e., about 34.2% identity, with a *Anopheles gambiae* peritrophin 1 protein (Accession #

AAC39127). Comparison of SEQ ID NO:1887 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:1887 showed the most homology, i.e., about 37% identity, with a *Anopheles gambiae* chloride intracellular channel 2 (Accession # AF030431). Percent identity calculations were performed using GCG version 9.0 using  
 5 default parameters.

In order to express the full-length putative PL3 protein, the entire coding region was amplified by PCR and then ligated into the *E. coli* expression vector pTrcHisB, available from Invitrogen, as follows. Forward primer PL3FE, which corresponds to nucleotides 70-93 of SEQ ID NO:1887, having the sequence 5' CGG GAT CCC GAA  
 10 TAT GCT GAC GTA GAT GTG TG 3', denoted SEQ ID NO:1944, and having a *Bam*HI restriction endonuclease site indicated in bold, was used in conjunction with reverse primer PL3RE, which is complementary to nucleotides 245-269 of SEQ ID NO:1887, having the sequence 5' GGA ATT CTG TTT TAT TCT GGT TGG TAA CAT TC 3', denoted herein as SEQ ID NO:1945 and having an *Eco*RI restriction endonuclease site  
 15 indicated in bold, in a PCR reaction using SEQ ID NO:1887 as the template under standard PCR reaction conditions and the following thermocycling conditions: (1) 94°C for 30 seconds, (2) 25 cycles of 94°C for 10 seconds, 55°C for 10 seconds and 72°C for 3 minutes. The reaction product was separated on a 1.5% agarose gel, and a band corresponding to an approximately 200 nucleotide molecule, as visualized by agarose gel  
 20 electrophoresis and ethidium bromide staining, was cut from the gel and purified using the QIAquick Gel Extraction Kit as described above.

The product of the PCR reaction was the digested with *Bam*HI and *Eco*RI restriction endonucleases, available from New England BioLabs, Inc. for 18 hours at

37 °C, purified using the QIAquick Nucleotide Removal Kit, available from Qiagen, and ligated into the vector pTrcHisB which had been similarly digested, treated with shrimp alkaline phosphatase, available from New England BioLabs, Inc., for 30 minutes at 37°C, and purified. Following standard transformation procedures into *E. coli* BL-21

- 5 competent cells, a bacterial clone containing the plasmid pTrcHisB-PL3 was isolated. DNA sequence analysis of the clone confirmed that 70-269 of SEQ ID NO:1887 had been successfully ligated into the pTrcHisB expression vector in frame with the N-terminal T7 Tag epitope encoded by the vector. The recombinant protein encoded thereby is predicted to be 97 amino acids in length and have a molecular mass of 10.9 kDa,
- 10 including the T7 Tag and have a pI of 4.08.

- A recombinant PL3 protein was expressed as follows. Five mls of Luria broth were inoculated with a glycerol stock of *E. coli* BL-21 competent cells, available from Novagen, Madison, WI, that had been transformed with the pTrcHisB-PL3 plasmid prepared as described above and allowed to grow overnight at 37°C under selection with
- 15 100 µg/ml ampicillin. A 1 ml aliquot of this culture was then used to inoculate 10 mls of fresh Luria broth containing 100 µg/ml ampicillin and the culture was allowed to grow to an approximate OD reading of 0.5. A 1 ml aliquot of the culture was removed, the cells were pelleted by centrifugation and the supernatant discarded. The cells were resuspended in a solution of 100 µl PBS and 100 µl of 2X SDS-PAGE loading buffer
- 20 (100 mM Tris pH 6.8, 4% SDS, 20% glycerol, 0.02% bromophenol blue, and 10% 2-mercaptoethanol). Following removal of the 1 ml aliquot described above, IPTG was added to the remaining 9 ml culture to a final concentration of 5 mM of IPTG, the culture

was incubated at 37°C for an additional 60 minutes, 1 ml was removed and the OD measured at approximately 0.6. The cells in this 1 ml sample were then pelleted by centrifugation and resuspended in a solution of 120 µl of PBS and 120 µl of SDS-PAGE loading buffer. Equal volumes of the IPTG-induced and uninduced lysates were loaded  
5 onto a 14% Tris-Glycine SDS-PAGE gel, available from Novex, San Diego, CA.

Following electrophoresis, the proteins were transferred from the SDS-PAGE gel to a nitrocellulose membrane and a Western blot analysis was performed using the T7 tag antibody, available from Novagen, which revealed an approximately 18 kDa protein was induced by IPTG. The fact that the recombinant PL3 protein ran at a higher molecular  
10 weight than predicted is consistent with previous published results for other peritrophin proteins, and is thought to be due in part to the characteristically low pI of these proteins (Tellam *et al.*, (1999) Peritrophic Matrix Proteins, Insect Biochemistry and Molecular Biology, 29:87-101). Sequence analysis of this protein indicates that it contained the N-terminal T7 Tag encoded by the vector.

15 Four flasks, each containing 1 liter of Luria broth with 100 µg/ml ampicillin were inoculated with a starter culture of 5 ml of *E. coli* BL-21 cells transformed with the pTrcHisB-PL3 plasmid as described above. The cultures were allowed to grow at 37°C until the optical density reached approximately 0.500, at which time a 1 ml aliquot was removed from each flask as the pre-induction sample. IPTG was added to each 1 liter  
20 flask to a final concentration of 0.5 mM and the cultures allowed to grow at 37°C for 135 additional minutes, at which time a 1 ml aliquot was removed from each flask as the post-induction sample. The 1 ml aliquots were centrifuged, the supernatants were discarded and the pellets were resuspended in 100µl 2X SDS-PAGE loading buffer per each 0.5

optical density units measured. The pre-induction and post induction samples were then tested for recombinant PL3 protein expression using the standard Western blot techniques and the T7 Tag antibody described above. A protein running at approximately 18 kDa was detected in the post-induced but not in the pre-induced samples.

- 5           The cells from the remaining 4 liters of culture were centrifuged, the supernatants were discarded and the cell pellets were combined and resuspended in 120 mls of buffer A (50 mM Tris, PH 8.0, 20 mM NaCl, 1 mM phenylmethylsulfonyl fluoride (PMSF)). The sample was then passed through a microfluidizer five times then rocked at 4°C for 20 minutes. The sample was then centrifuged for 30 minutes and the supernatant collected.
- 10       Western blot analysis of the supernatant showed that the recombinant PL3 protein was soluble in the first buffer A extraction. The buffer A supernatant containing the recombinant PL3 protein was then further purified by a nickel column, a Q2 anion exchange chromatography column, and cation exchange chromatography, using techniques well known to those of skill in the art.

15       Example 17

This Example describes the further characterization of a Peritrophin-like sequence cDNA, referred to herein as PL4, isolated by EST sequencing described in Example 1.

- A cDNA designated clone 2244-71 was isolated from the unsubtracted HMT library as described in Example 1. Analysis of clone 2244-71 indicated that the cDNA,
- 20       denoted nCfPL4<sub>974</sub>, is about 974 nucleotides in length, having a coding strand with nucleic acid sequence SEQ ID NO:1892 and a complementary sequence having SEQ ID NO:1893. Translation of SEQ ID NO:1892 suggests that nucleic acid molecule nCfPL4<sub>974</sub> encodes a partial-length Peritrophin-like protein of 285 amino acids.

Additional sequence corresponding to the 5' end was isolated by PCR using the RACE cDNA pool described in Example 3 as the template, as follows. Adapter Primer 1, i.e. SEQ ID NO:1933, was used as the forward primer in conjunction with reverse primer PL4-R1, which is complementary to nucleotides 229-251 of SEQ ID NO:1892, having a

5 nucleic acid sequence 5' GAT ATC CAC TTT GAT CAG CGC AC 3', denoted herein as SEQ ID NO:1946 in a PCR reaction under standard PCR reaction conditions and the following thermocycling conditions: (1) 94°C for 30 seconds, (2) 5 cycles of 94°C for 10 seconds and 72°C for 4 minutes, (3) 5 cycles of 94°C for 10 seconds and 70°C for 4 minutes, (4) 25 cycles of 94°C for 10 seconds then 68°C for 4 minutes. The products of

10 this reaction were diluted 1:50 and used as template in a second PCR reaction using Adapter Primer 2, i.e. SEQ ID NO:1935 as the forward primer and reverse primer PL4-R2, which is complementary to nucleotides 58-78 of SEQ ID NO:1892, having a nucleic acid sequence 5' GGT ACT ACT CCT GGT GCG GGC 3', denoted herein as SEQ ID NO:1947, using the thermocycling conditions described for the first PCR reaction. The

15 products of this reaction were gel purified as previously described and the fragment was ligated into the pCR II TA Cloning vector, available from Qiagen, and sequenced to reveal of fragment of approximately 150 nucleotides in length. Sequence analysis revealed that nucleotides 68-146 of the fragment had 100% identity with nucleotides 1-79 of nCfPLA<sub>974</sub>. The two sequences were aligned to form a contiguous sequence of about

20 1043 nucleotides in length, referred to as nCfPLA<sub>1043</sub>, having a coding strand with SEQ ID NO:1894 and a complementary strand having SEQ ID NO:1895. However, the contiguous sequence does not appear to encode a starting methionine in the predicted protein sequence, thus, a second attempt to isolate the remaining coding sequences at the



5' end was performed as follows. A first PCR reaction was performed with Adapter Primer 1 as the forward primer and PL4-R2 as the reverse primer using the RACE cDNA pool as the template under the thermocycling conditions described above. The products of this reaction were diluted 1:50 and used as the template in a second PCR reaction which used Adapter Primer 2 as the forward primer and reverse primer PL4-R4, which is complementary to nucleotides 58-80 of SEQ ID NO:1894, having the nucleic acid sequence 5' CCG TCG ACA TTA AAC TCA CCA TC 3', denoted SEQ ID NO:1948, under the thermocycling conditions described for the first PCR reaction. The products of this reaction were gel purified as previously described and the fragment was ligated into the pCR II TA Cloning vector, available from Qiagen, and sequenced to reveal of fragment of approximately 100 nucleotides in length. Sequence analysis revealed that nucleotides 21-101 of the fragment had 100% identity with nucleotides 1-81 of SEQ ID NO:1892. The two sequences were aligned to form a contiguous sequence that is 1062 nucleotides in length, referred to herein as nCfPL4<sub>1062</sub>, having a coding strand with SEQ ID NO:1896 and a complementary strand with SEQ ID NO:1898. Translation of SEQ ID NO:1896 suggests that nucleic acid molecule nCfPL4<sub>1062</sub> encodes a full-length Peritrophin-like protein of 285 amino acids, referred to herein as PCfPL4<sub>285</sub>, having an amino acid sequence represented by SEQ ID NO:1897, assuming the initiation codon spans from nucleotide 19 through nucleotide 21 of SEQ ID NO:1896 and the termination codon spans from nucleotide 874 through nucleotide 876 of SEQ ID NO:1896. The coding region encoding PCfPL4<sub>285</sub>, is represented by nucleic acid molecule nCfPL4<sub>855</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:1899

and a complementary strand with nucleic acid sequence represented by SEQ ID NO:1900. The amino acid sequence of SEQ ID NO:1897, predicts that PCfPL4<sub>285</sub> has an estimated molecular weight of about 31.4 kDa and an estimated isoelectric point (pI) of about 6.99.

Comparison of amino acid sequence SEQ ID NO:1897 with amino acid sequences reported in GenBank indicates that SEQ ID NO:1897 showed the most homology, i.e., about 31.5% identity, with a *Drosophila melanogaster* Gasp precursor (Accession # AAD09748). Comparison of SEQ ID NO:1896 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:1896 showed the most homology, i.e., about 39.4% identity, with a *Drosophila melanogaster* Gasp precursor (Accession #AF070734 ).

Percent identity calculations were performed using GCG version 9.0 using default parameters.

A Northern Blot analysis was conducted as described in Example 4 to determine whether PL4 mRNA is expressed only in certain life stages of the flea life cycle and whether PL4 mRNA is expressed only in HMT tissue. Total RNA was extracted from eggs, first, third, and wandering larvae, pupae, unfed adults, and adults fed on cat blood for 0.25, 2, 8, and 24 hours. In addition, total RNA was extracted from hindguts and Malpighian tubules extracted from 24 hour cat blood-fed adult fleas, and from the remaining body parts following the removal of hindguts and Malpighian tubules. Each RNA sample was separated by gel electrophoresis, transferred to nylon membranes and hybridized with  $\alpha$ -<sup>32</sup>P-ATP labeled nCfPL4<sub>974</sub> under the Northern Blotting conditions described in Example 4.

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The results of the Northern blot assay are complex. Although stringent conditions were used, several bands with distinct expression patterns were seen. An approximately 1600 bp message was detected in the egg, first instar, third instar and wandering larval stages only. An approximately 1500 bp message was detected in all lifestages and adult fed timepoints, but with the strongest signals in the egg, first instar larval, and unfed adult stages. A third message, which ran approximately 1200 bp, was detected in the egg, first instar larval, pupal, and adult lifestages, including all unfed and fed adult timepoints. All three of the messages detected were seen only in the HMT tissues, and were not detected in the carcass tissues.

The detection of three mRNAs instead of one may be the result of the expression of three highly homologous transcripts. It has been reported in the literature that peritrophin gene families have been found that consist of a number of highly related genes (See Schorderet *et al.*, 1998, cDNA and deduced amino acid sequences of a peritrophic membrane glycoprotein, 'peritrophin-48', from the larvae of *Lucilia cuprina*, Insect Biochemistry and Molecular Biology 28, 99-111). It is possible that these transcripts represent the products of such a family or that the messages are the RNA products of alternative splicing of a single gene locus.

#### Example 18

This Example describes the further characterization of a synaptic vesicle 2B-like sequence cDNA, isolated by EST sequencing described in Example 1.

A cDNA designated clone 2104-59 was isolated from the subtracted HMT library as described in Example 1, denoted herein as SEQ ID NO:358. DNA from clone 2104-59 was purified, and the insert used for plaque hybridization screening of the unsubtracted

HMT cDNA library as follows. The insert from clone 2104-59 was excised by digestion with *EcoRI*, separated by agarose gel electrophoresis and purified using the QiaQuick Gel Extraction kit, available from Qiagen. A Megaprime DNA labeling kit, available from Amersham Pharmacia, was used to incorporate  $\alpha$ -<sup>32</sup>P-labeled dATP into the random-primed probe mix. Hybridization and plaque purification were performed as previously described which resulted in the isolation of a clone containing an about 1875 nucleotide synaptic vesicle 2B-like sequence, referred to herein as nCfSVP<sub>1875</sub>, having a coding strand with nucleic acid sequence SEQ ID NO:1901 and a complementary sequence having SEQ ID NO:1903. Translation of SEQ ID NO:1901 suggests that nucleic acid molecule nCfSVP<sub>1875</sub> encodes a full-length synaptic vesicle 2B-like protein of 530 amino acids, referred to herein as PCfSVP<sub>530</sub>, having an amino acid sequence represented by SEQ ID NO:1902, assuming the initiation codon spans from nucleotide 44 through nucleotide 46 of SEQ ID NO:1901 and the termination codon spans from nucleotide 1634 through nucleotide 1636 of SEQ ID NO:1901. The coding region encoding PCfSVP<sub>530</sub> is represented by nucleic acid molecule nCfSVP<sub>1590</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:1904 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:1905. The amino acid sequence of SEQ ID NO:1902, predicts that PCfSVP<sub>530</sub> has an estimated molecular weight of about 58.7 kDa and an pI of about 7.61.

Comparison of amino acid sequence SEQ ID NO:1902 with amino acid sequences reported in GenBank indicates that SEQ ID NO:1902 showed the most homology, i.e., about 32% identity, with a *Drosophila melanogaster* BACR7A4.y (Accession #

CAB51685). Comparison of SEQ ID NO:1901 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:1901 showed the most homology, i.e., about 39% identity, with a *Rattus norvegicus* synaptic vesicle protein 2B (SVP2B) mRNA (Accession # L10362). Percent identity calculations were performed using GCG version 9.0 using default parameters.

#### Example 19

This Example describes the further characterization of a Voltage-Gated Chloride Channel-like sequence cDNA, isolated by EST sequencing described in Example 1.

A cDNA designated clone 2108-09 was isolated from the unsubtracted HMT library as described in Example 1. Analysis of clone 2108-09 indicated that the cDNA, denoted nCfVGCC<sub>381</sub>, is about 381 nucleotides in length, having a coding strand with nucleic acid sequence SEQ ID NO:1906 and a complementary sequence having SEQ ID NO:1907. Translation of SEQ ID NO:1906 suggests that nucleic acid molecule nCfVGCC<sub>381</sub> encodes a partial-length Voltage-Gated Chloride Channel-like protein of 126 amino acids. Additional sequence corresponding to the 5' end was isolated by hybridization and PCR as follows.

The insert from clone 2108-09 was excised by digestion with *EcoRI*, separated by agarose gel electrophoresis and purified using the QiaQuick Gel Extraction kit, available from Qiagen. A Megaprime DNA labeling kit, available from Amersham Pharmacia, was used to incorporate  $\alpha$ -<sup>32</sup>P-labeled dATP into the random-primed probe mix.

Hybridization and plaque purification were performed on the unsubtracted HMT cDNA library as previously described which resulted in the isolation of a clone containing an

about 2191 nucleotide VGCC-like sequence, referred to herein as nCfVGCC<sub>2191</sub>, having a coding strand with nucleic acid sequence SEQ ID NO:1908 and a complementary sequence having SEQ ID NO:1909. Translation of SEQ ID NO:1908 suggests that nucleic acid molecule nCfVGCC<sub>2191</sub> encodes a partial s VGCC-like protein of 595 amino acids.

In order to isolate the remaining coding regions at the 5' end, a PCR was performed using the RACE cDNA pool, prepared as described in Example 3, as the template as follows. Adapter Primer 1 was used as the forward primer in conjunction with reverse primer VGCC-R1, which is complementary to the nucleotides 1482-1503 of SEQ ID NO:1908, having a nucleic acid sequence 5' CGA TCA TGC GTC TAG CAT TGG C 3', denoted herein as SEQ ID NO:1949 under standard PCR reaction conditions and the following thermocycling conditions: (1) 94°C for 30 seconds, (2) 5 cycles of 94°C for 10 seconds and 72°C for 4 minutes, (3) 5 cycles of 94°C for 10 seconds and 70°C for 4 minutes, (4) 25 cycles of 94°C for 10 seconds and 68°C for 4 minutes. The reaction products were separated on an agarose gel and a band corresponding to an approximately 1970 nucleotide molecule was isolated, purified using a Gel Purification Kit, available from Qiagen, ligated into the pCR II TA cloning vector, available from Invitrogen, and sequenced using an ABI PRISM 377 automatic DNA Sequencer. Sequence analysis revealed an approximately 1968 nucleotide fragment, referred to as nCfVGCC<sub>1968</sub>, having a coding strand with SEQ ID NO:1910 and a complementary strand with SEQ ID NO:1911. Sequence analysis also revealed that nucleic acid molecule nCfVGCC<sub>1968</sub> does not encode a start codon, thus, a second 5' RACE PCR was performed as follows in order to isolate additional sequence. Adapter Primer 1 was used

as the forward primer in conjunction with reverse primer VGCC-R4 primer which is complementary to nucleotides 350-372 of SEQ ID NO:1910, having a nucleic acid sequence 5' CCC GCC CCA GTT CTA GGT TGT CC 3', denoted herein as SEQ ID NO:1950, using the RACE cDNA pool prepared as described in Example 3 as the

5 template, and the PCR reaction and thermocycling conditions as described for the first PCR reaction. The products of this reaction were then diluted 1:50 in water and used as the template in a second PCR reaction with Adapter Primer 2 as the forward primer in conjunction with reverse primer VGCC-R2, which is complementary to nucleotides 134-153 of SEQ ID NO:1910, having a nucleic acid sequence 5' CAC ACC CAA CCT GAC

10 CAG GC 3', denoted herein as SEQ ID NO:1951, under the PCR reaction and thermocycling conditions as described for the first PCR reaction.

The products of this reaction were gel purified as previously described and the fragment was ligated into the pCR II TA Cloning vector, available from Qiagen, and sequenced to reveal of fragment of approximately 673 nucleotides in length, referred to

15 herein as nCfVGCC<sub>673</sub>, having a coding strand with SEQ ID NO:1912 and a complementary strand with SEQ ID NO:1913. Sequence analysis revealed that nucleotides 520-673 of the fragment had 100% identity with nucleotides 1-154 of SEQ ID NO:1910. The VGCC fragments were aligned to form a contiguous sequence that is 3126 nucleotides in length, referred to herein as nCfVGCC<sub>3126</sub>, having a coding strand

20 with SEQ ID NO:1914 and a complementary strand with SEQ ID NO:1916. Translation of SEQ ID NO:1914 suggests that nucleic acid molecule nCfVGCC<sub>3126</sub> encodes a full-length VGCC-like protein of 851 amino acids, referred to herein as PCfVGCC<sub>851</sub>, having

an amino acid sequence represented by SEQ ID NO:1915, assuming the initiation codon spans from nucleotide 168 through nucleotide 170 of SEQ ID NO:1914 and the termination codon spans from nucleotide 2721 through nucleotide 2723 of SEQ ID NO:1914. The coding region encoding PCfVGCC<sub>851</sub> is represented by nucleic acid molecule nCfVGCC<sub>2553</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:1917 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:1918. The amino acid sequence of SEQ ID NO:1915, predicts that PCfVGCC<sub>851</sub> has an estimated molecular weight of about 93.4 kDa and an estimated pI of about 7.35.

- 10           Comparison of amino acid sequence SEQ ID NO:1915 with amino acid sequences reported in GenBank indicates that SEQ ID NO:1915 showed the most homology, i.e., about 63.1% identity, with a *Oryctolagus cuniculus* (rabbit) chloride channel protein 3 (CLCN3) (Accession # AAB95163). Comparison of SEQ ID NO:1914 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:1914 showed the most
- 15           homology, i.e., about 61.3% identity, with a *Oryctolagus cuniculus* chloride channel protein 3 (CLCN3) mRNA (Accession # AF029348). Percent identity calculations were performed using GCG version 9.0 using default parameters.

- 20           A Northern Blot analysis was conducted as described in Example 4 to determine whether VGCC mRNA is expressed only in certain life stages of the flea life cycle and whether VGCC mRNA is expressed only in HMT tissue. Total RNA was extracted from eggs, first, third, and wandering larvae, pupae, unfed adults, and adults fed on cat blood for 0.25, 2, 8, and 24 hours. In addition, total RNA was extracted from hindguts and



Malpighian tubules extracted from 24 hour cat blood-fed adult fleas, and from the remaining body parts following the removal of hindguts and Malpighian tubules. Each RNA sample was separated by gel electrophoresis, transferred to nylon membranes and hybridized with  $\alpha$ -<sup>32</sup>P-ATP labeled nCfVGCC<sub>381</sub> under the Northern Blotting conditions described in Example 4. An approximately 3 kB band was detected in all lifestages and adult unfed and fed timepoints, however, the intensity of the signal did vary between stages with the strongest signals seen in the egg, unfed adult, and 0.25 hour fed adult stages, and the weakest signals seen in the 3rd instar larval and pupal stages. A strong signal was detectable in the 24 hour fed adult HMT tissues, but only a very weak signal was present in the carcass tissues.

#### Example 20

This Example describes the further characterization and expression of an Intersectin-like cDNA isolated by EST sequencing described in Example 2.

A cDNA designated clone 2225-23 was isolated from the unsubtracted HNC library as described in Example 2, denoted herein as SEQ ID NO:121. A Northern Blot analysis was conducted as described in Example 10 to determine whether clone 2225-23 mRNA is expressed exclusively in HNC tissues. For the hybridization step, a probe comprising the flea clone 2225-23 nucleic acid molecule was labeled with  $\alpha$ -<sup>32</sup>P-ATP using a DNA labeling kit, available from Amersham and added to the buffer at a concentration of approximately  $1 \times 10^6$  cpm/ml, and allowed to hybridize for about 14 to 18 hours at 42°C. The blot was then washed twice for 10 minutes per wash in 0.5X SSPE and 0.1% sarcosyl at 55°C and exposed to film for autoradiography. Analysis of the

developed film showed that there was greater expression of clone 2225-23 mRNA in HNC tissues compared to non-HNC tissues, indicating possible upregulation of clone 2225-23 in flea head and nerve cords.

#### Example 21

5           This Example describes the further characterization and expression of an Neuroendocrine Specific Protein C-like cDNA isolated by EST sequencing described in Example 2.

          A cDNA designated clone 2249-19 was isolated from the unsubtracted HNC library as described in Example 2, denoted herein as SEQ ID NO:1775. A Northern Blot  
10   analysis was conducted as described in Example 10 to determine whether clone 2249-19 mRNA is expressed exclusively in HNC tissues. For the hybridization step, a probe having the nucleic acid sequence of clone 2249-19 was generated as follows. A PCR reaction was conducted using forward primer 2249-19for, having a nucleotide sequence 5' AGT CGC ATA GTG CAC TTC TGA ATG 3', denoted herein as SEQ ID NO:1954,  
15   and reverse primer 2249-19rev, having a nucleotide sequence 5' CTG ACA TCT GTT TCC ACA GCT C 3', denoted herein as SEQ ID NO:1955, using the HNC cDNA library prepared as described in Example 2 as the template under standard PCR reaction conditions and the following thermocycling conditions: (1) one minute at 95°C, (2) two cycles of 94°C for 10 seconds, 50°C for 20 seconds, and 72°C for 20 seconds, (3) thirty  
20   cycles of 94°C for 10 sec, 53°C for 20 sec, 72°C for 40 sec. The PCR product was ligated into the TA vector using a TA cloning kit, available from Invitrogen and the clone was digested with *EcoR*I enzyme, and purified from an agarose gel. The purified nucleic acid

molecule was labeled with  $\alpha$ -<sup>32</sup>P-ATP using a DNA labeling kit, available from Amersham and added to the buffer at a concentration of approximately 1 x 10<sup>6</sup> cpm/ml, and allowed to hybridize for about 14 to 18 hours at 42°C. The blot was then washed twice for 10 minutes per wash in 0.5X SSPE and 0.1% sarcosyl at 55°C and exposed to film for autoradiography. Analysis of the developed film showed that there was expression of clone 2249-19 mRNA in HNC tissues and non-HNC tissues with 2 bands evident; one at approximately 1.5 Kb and one at approximately 2.5 Kb.

#### Example 22

This Example describes the further characterization and expression of an anoxia upregulated protein-like cDNA isolated by EST sequencing described in Example 2.

A TA clone from the HNC EST library described in Example 2 designated clone 2218-95, denoted herein as SEQ ID NO:1858 was sequenced using standard sequencing methods and shown to contain a non-full length nucleic acid molecule having significant homology to anoxia upregulated protein (AUP) genes. Additional sequence encoding an AUP gene was isolated as follows. A hybridization probe containing the nucleic acid sequence of SEQ ID NO:1858 was constructed as follows. A PCR reaction was conducted using forward primer 2218-95for, having a nucleotide sequence 5' AAT AGT GAT GTT GTA AGA GTT AGG 3', denoted herein as SEQ ID NO:1956, and reverse primer 2218-95rev, having a nucleotide sequence 5' GTT TAA TAT TGC ATG TTT ATT CAT TAA AA 3', denoted herein as SEQ ID NO:1957, using the HNC cDNA library prepared as described in Example 2 as the template under standard PCR reaction conditions and the following thermocycling conditions: (1) one minute at 95°C, (2) thirty

cycles of 94°C for 10 sec, 55°C for 20 sec, 72°C for 20 sec. The PCR product was ligated into the TA vector using a TA cloning kit, available from Invitrogen and the clone was digested with *EcoR*I enzyme, and purified from an agarose gel. The purified nucleic acid molecule was labeled with  $\alpha$ -<sup>32</sup>P-ATP using a DNA labeling kit, available from

5 Amersham.

The <sup>32</sup>P  $\alpha$ -dATP labeled probe was used in a standard plaque lift hybridization procedure to isolate a clone from the HNC lambda-ZAP unsubtracted cDNA library described in Example 2. Hybridization was conducted as described in Example 12 and a plaque that hybridized strongly to the probe was isolated, purified and sequenced as  
10 described in Example 12. Sequencing revealed that the clone contained a nucleic acid molecule of about 1181 nucleotides, referred to herein as nCfAUP<sub>1181</sub>, having a

nucleotide sequence denoted herein as SEQ ID NO:1919. The complement of SEQ ID NO:1919 is represented herein as SEQ ID NO:1921.

Translation of SEQ ID NO:1919 suggests that nucleic acid molecule nCfAUP<sub>1181</sub>  
15 encodes a full-length AUP protein of 102 amino acids, referred to herein as PCfAUP<sub>102</sub>, having an amino acid sequence represented by SEQ ID NO:1920, assuming the initiation codon spans from nucleotide 127 through nucleotide 129 of SEQ ID NO:1919 and the termination codon spans from nucleotide 433 through nucleotide 435 of SEQ ID NO:1919. The coding region encoding PCfAUP<sub>102</sub> is represented by nucleic acid  
20 molecule nCfAUP<sub>306</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:1922 and a complementary strand with nucleic acid sequence represented

by SEQ ID NO:1923. The amino acid sequence of PCfAUP<sub>102</sub> predicts that PCfAUP<sub>102</sub> has an estimated molecular weight of about 11.9 kDa and an estimated pI of about 10.5.

Comparison of amino acid sequence SEQ ID NO:1920 with amino acid sequences reported in GenBank indicates that SEQ ID NO:1920 showed the most homology, i.e.,

5 about 52% identity, with a *Drosophila melanogaster* anoxia upregulated protein, GenBank Accession No. AAD38397. Percent identity calculations were performed using GCG version 9.0 using default parameters. Blast comparison of nucleic acid sequence SEQ ID NO:1919 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:1919 showed the most homology to a clone from human chromosome 14q31  
10 region containing gene for neurexin III, GenBank #AC007056. Pairwise identity could not be performed as the human clone in GenBank is too large to load into GCG version 9.0.

### Example 23

This Example describes the further characterization of a neuroendocrine specific  
15 7B2 polypeptide, isolated by EST sequencing described in Example 2.

A cDNA designated clone 2211-21 was isolated from the subtracted HNC library as described in Example 2, denoted herein as SEQ ID NO:92. DNA from clone 2211-21 was purified, and the insert used for plaque hybridization screening of the unsubtracted HMT cDNA library as follows. The insert from clone 2211-21 was excised by digestion  
20 with *Eco*RI, separated by agarose gel electrophoresis and purified using the QiaQuick Gel Extraction kit, available from Qiagen. A Megaprime DNA labeling kit, available from Amersham Pharmacia, was used to incorporate  $\alpha$ -<sup>32</sup>P-labeled dATP into the random-

primed probe mix. The  $^{32}\text{P}$   $\alpha$ -dATP labeled probe was used in a standard plaque lift hybridization procedure to isolate a clone from the HNC lambda- ZAP unsubtracted cDNA library, prepared as described in Example 2. The following hybridization conditions were used. Hybond-N filters, available from Amersham, were hybridized with

5 about  $2 \times 10^6$  counts per minute (cpm) per ml of the probe in 50 ml of hybridization solution (5X SSPE, 25mM EDTA pH 8.0, 5X Denhardt's reagent, 1.2% SDS, 0.020 mg/mL salmon sperm DNA) at 55°C for about 48 hours. The filters were washed once in 50mL 4X SSPE, 1% SDS for 15 minutes at 55°C, once in 50 mL 2X SSPE, 1% SDS for 10 minutes at 55°C, and washed twice in 50 mL 0.5X SSPE, 0.5% SDS for 10 minutes at

10 55°C. The filters were then subjected to autoradiography. One plaque that hybridized strongly to the probe was isolated and subjected to in vivo excision using the Stratagene Ex-Assist™ helper phage system and protocols. Miniprep DNA was prepared from the positive clone using a Miniprep kit and protocol, available from Qiagen, Chatsworth, CA, and sequenced using standard sequencing procedures. The clone, referred to as

15 nCf7B2<sub>2161</sub> contains a nucleic acid molecule of about 2161 nucleotides in length, having a coding strand with nucleic acid sequence SEQ ID NO:1924 and a complementary sequence having SEQ ID NO:1926.

Translation of SEQ ID NO:1924 suggests that nucleic acid molecule nCf7B2<sub>2161</sub> encodes a full-length 7B2-like protein of 267 amino acids, referred to herein as

20 PCf7B2<sub>267</sub>, having an amino acid sequence represented by SEQ ID NO:1925, assuming the initiation codon spans from nucleotide 107 through nucleotide 109 of SEQ ID NO:1924 and the termination codon spans from nucleotide 908 through nucleotide 910 of

SEQ ID NO:1924. The coding region encoding PCf7B2<sub>267</sub>, is represented by nucleic acid molecule nCf7B2<sub>801</sub>, having a coding strand with the nucleic acid sequence represented by SEQ ID NO:1927 and a complementary strand with nucleic acid sequence represented by SEQ ID NO:1928. The amino acid sequence of SEQ ID NO:1925, predicts that

5 PCf7B2<sub>267</sub> has an estimated molecular weight of about 31 kDa and an estimated pI of about 5. Analysis of PCf7B2<sub>267</sub> suggests the presence of a signal peptide encoded by a stretch of amino acids spanning from about amino acid 1 through amino acid 20. The proposed mature protein, referred to herein as PCf7B2<sub>247</sub> contains 247 amino acids, designated SEQ ID NO:1930, and is encoded by a nucleic acid molecule referred to as

10 nCf7B2<sub>741</sub>, having a coding strand with SEQ ID NO:1929 and a complementary strand with SEQ ID NO:1931.

Comparison of amino acid sequence SEQ ID NO:1925 with amino acid sequences reported in GenBank indicates that SEQ ID NO:1925 showed the most homology, i.e., about 39% identity, with a *Drosophila melanogaster* protein, GenBank Accession No.

15 AAF52036. Percent identity calculations were performed using GCG version 9.0 using default parameters. Blast comparison of nucleic acid sequence SEQ ID NO:1924 with nucleic acid sequences reported in GenBank indicates that SEQ ID NO:1924 showed the most homology to a human chromosome 19, cosmid R28204 clone, GenBank #Accession No. AC006132. Pairwise identity could not be performed as the human clone in

20 GenBank is too large to load into GCG version 9.0, however, the BLAST score was 0.20, which is not considered to be significant level of identity.

A Northern Blot analysis was conducted as described in Example 10 to determine whether 7B2 mRNA is expressed exclusively in HNC tissues. For the hybridization step, a probe having the nucleic acid sequence of clone 2211-21 was generated as follows. A PCR reaction was conducted using forward primer 2211-21for, having a nucleotide sequence 5' GCG CCA TGA AGA TTT CAG GCG 3', denoted herein as SEQ ID NO:1958, and reverse primer 2211-21rev, having a nucleotide sequence 5' AAG TGC AAT GAA TCA TCA GCA AG 3', denoted herein as SEQ ID NO:1959, using the HNC cDNA library prepared as described in Example 2 as the template under standard PCR reaction conditions and the following thermocycling conditions: (1) one minute at 95°C, (2) five cycles of 94°C for 10 seconds, 50°C for 20 seconds, and 72°C for 20 seconds, (3) thirty cycles of 94°C for 10 sec, 53°C for 20 sec, 72°C for 40 sec. The PCR product was ligated into the TA vector using a TA cloning kit, available from Invitrogen and the clone was digested with *Eco*R1 enzyme, and purified from an agarose gel. The purified nucleic acid molecule was labeled with  $\alpha$ -<sup>32</sup>P-ATP using a DNA labeling kit, available from Amersham and added to the buffer at a concentration of approximately 1 x 10<sup>6</sup> cpm/ml, and allowed to hybridize for about 14 to 18 hours at 42°C. The blot was then washed twice for 10 minutes per wash in 0.5X SSPE and 0.1% sarcosyl at 55°C and exposed to film for autoradiography. Analysis of the developed film showed that after 2.5 days of exposure clone 2211-21 mRNA was expressed exclusively in HNC tissue.

While various embodiments of the present invention have been described in detail, it is apparent that modifications and adaptations of those embodiments will occur to those skilled in the art. It is to be expressly understood, however, that such



modifications and adaptations are within the scope of the present invention, as set forth in the following claims:

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